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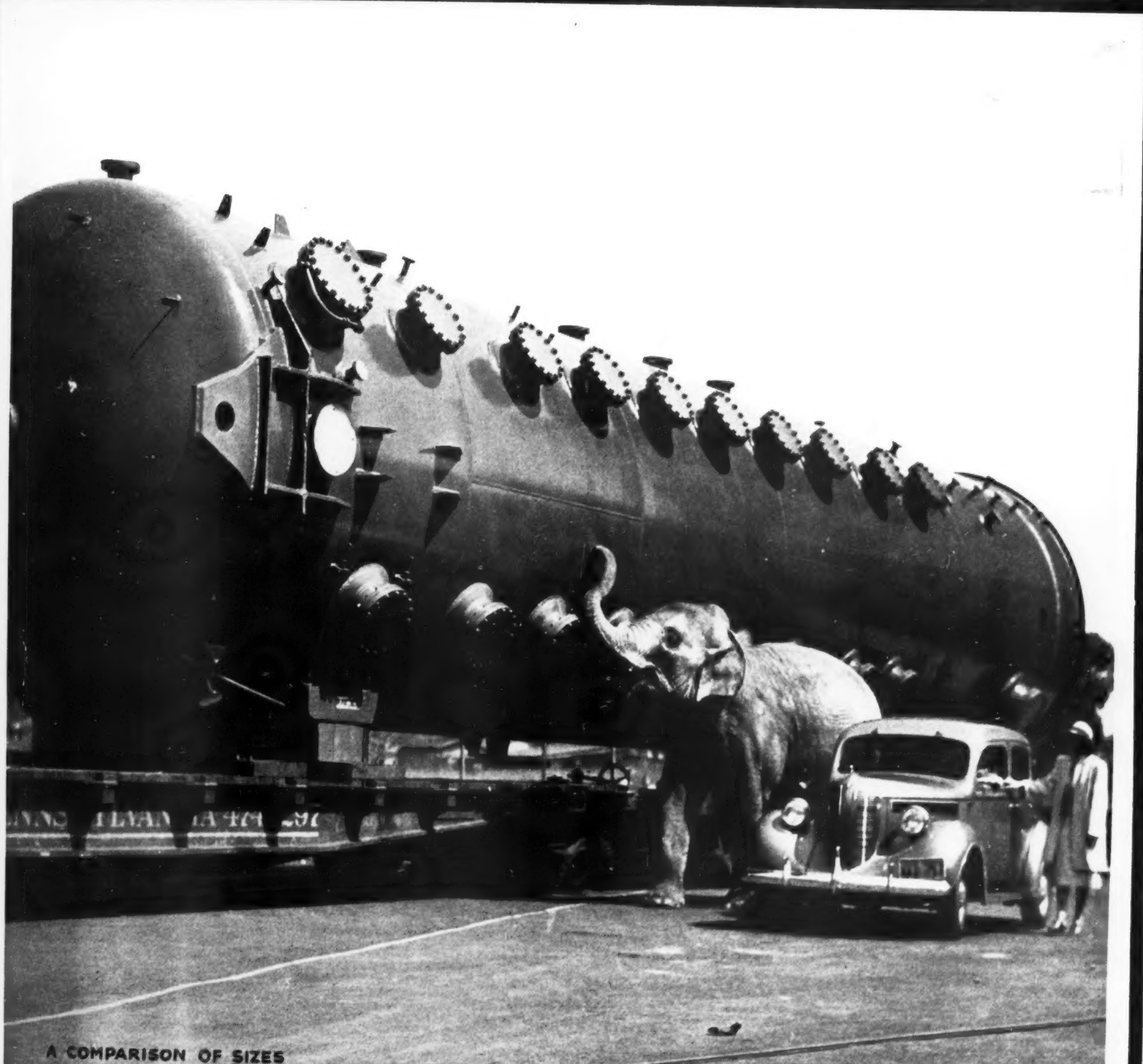

A COMPARISON OF SIZES
(See Index Page)

ON THE COVER

CONTRARY to usual practice, most of the equipment for the new refinery of the Richfield Oil Corporation at Watson, Calif., was fabricated in the contractor's shops at Alhambra, Calif., and shipped to the refinery site assembled. Vessels such as the one shown on the cover gave rise to many transportation complications; and it was necessary to enforce 1-way traffic on the 2-track rail line while they were in transit.

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IN THIS ISSUE

SINCE the days when the art of building was in its infancy, marble has been one of the finest, decorative architectural materials at man's disposal. Scientists have now found a way to make it increasingly attractive by cutting selected varieties so that artificial light placed behind thin slabs of the stone will accentuate the beauty of its structure and coloring. Our leading article by Robert G. Skerrett describes this interesting development.

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ENGINEERS the country over are watching with interest the rehabilitation of the Austin Dam. Long a white elephant, this 46-year-old structure is being given a new and more solid foundation and otherwise is being strengthened to fit it for useful service. Modern subsurface technique is being brought to bear in a manner that would amaze the original builders, were they permitted to witness its execution. The article begins on page 5895.

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IN RECENT years the shot drill has proved itself a very adaptable machine. Following the lead of a western metal mine, a contractor on the new Delaware River Aqueduct has employed a 48-inch Calyx drill to sink a pilot shaft 300 feet deep. The enlarging of it to full size will be a short and comparatively inexpensive operation.

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TO PUT together a $5,000,000 processing plant and have it go into operation without a shutdown for adjustment is no mean accomplishment. Yet that was done in the case of the new refinery of the Richfield Oil Corporation. Highlights of the plant and of its construction are given in the article starting on page 5907.

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Making Marble Glow from Within

Robert G. Skerrett

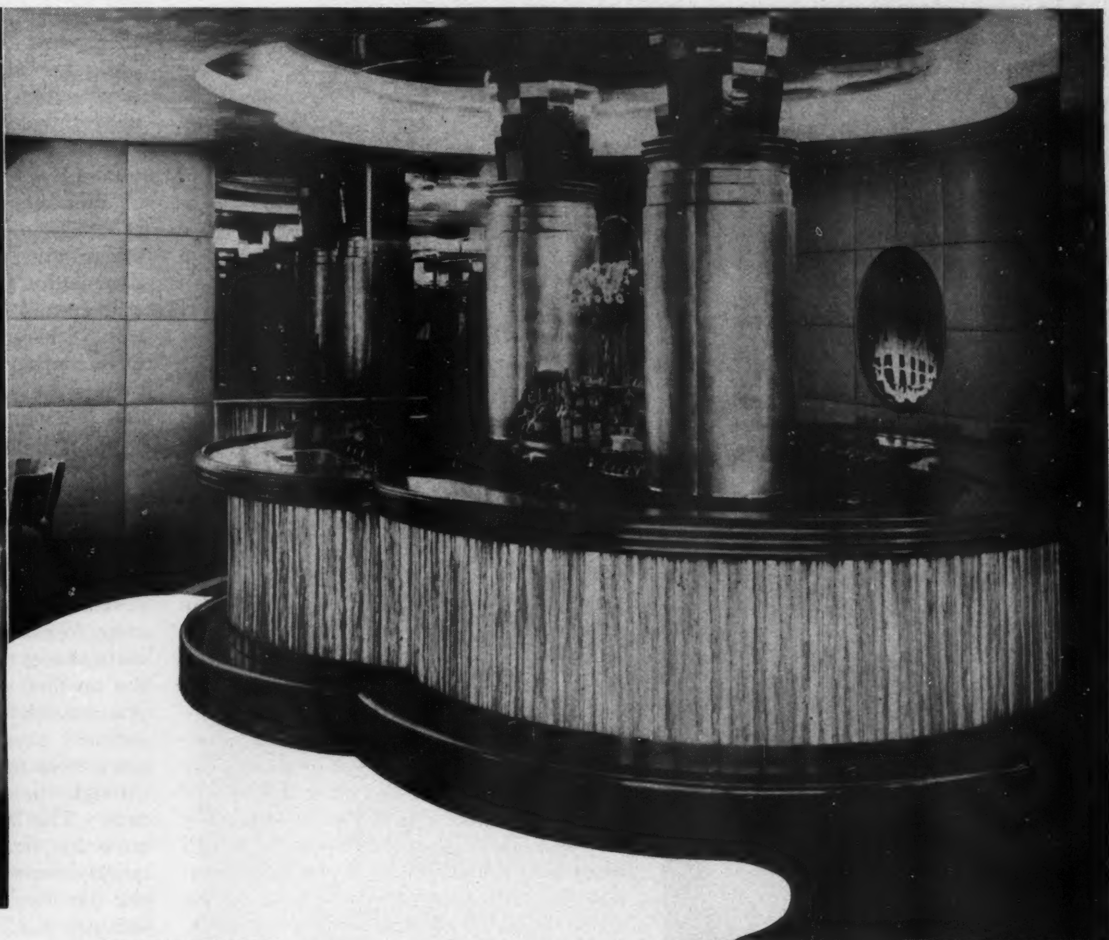
WHERE HUGE BLOCKS ARE QUARRIED

An underground chamber in a Vermont marble quarry from which has come the stone for many beautiful structures, including the Supreme Court Building in Washington. Blocks weighing more than 80 tons have been raised from this opening. Note the different lengths of steel used in drilling closely spaced holes which make it possible to break loose large blocks with wedges. Marble suitable for Lumar is also obtained from Colorado.

MARBLE heretofore has appealed to most of us because of its coloring, markings, and visible texture as revealed to us by the incident rays of light. For the same reasons it has been utilized for many centuries by architects, sculptors, and builders to impart beauty, dignity, or impressiveness to the innumerable works of their hands. In short, the material has won its widely deserved recognition largely because of its superficial characteristics as distinguished from its strength and durability.

No doubt, within that protracted span of man's creative and constructive efforts, some imaginative minds must have wondered what might be the measure of beauty hidden within the opaque mass of the marble and placed there while the substance was undergoing its formative evolution. Not until recently, however, have the features of the stone's internal substance been made visible to the eye by changing that darkened interior into a luminous mass capable of disclosing the coloring and the tracery implanted there by nature in the eons gone. Research has made this amazing transformation possible. Light has supplanted darkness. This has been achieved not by recourse to impregnating chemicals but, strange as it may seem, by skillfully utilizing the very structural characteristics that have distinguished marble since primordial times.

Marble was born of limestone when the shrinking and cooling of the earth's crust subjected the parent rock to great heat and tremendous pressures. Those terrestrial stresses changed the granules of the sedimentary limestone into granular crystals of calcium carbonate, commonly known as calcite; and in this respect marble is notably different from its geological source rock. Calcite is the major constituent of marble: and pure calcite may be quite as transparent as the best of optical glass. The calcite crystals are very minute; and yet they are so rigidly interlocked as to produce a substance capable of withstanding continuous exposure to the changing weather and of otherwise meeting the builder's requirements. Intimate as this bonding of the associate crystals is, still they are separated from one another by air films that have the microscopic thickness of millimicrons which can be represented as equivalent parts of an inch only by using a decimal point followed by seven naughts before adding the first numeral. These infinitely thin air films, however, now have an important function to perform in helping to illumine the internal



A STORE FRONT

The attractive effect (left) has been obtained by using Lumar marble for the front of a jewelry store in Lansing, Mich. Even a Carrie Nation might hesitate to destroy the beauty of such an ornate drinking place as that shown at the right, above. The banded front is composed of striated marble illuminated from behind to bring out the hidden color. Ordinary electric-light bulbs provide the illumination, the wattage used depending upon whether a soft or a bright glow is desired.

mass of a slab of marble and so cause it to glow.

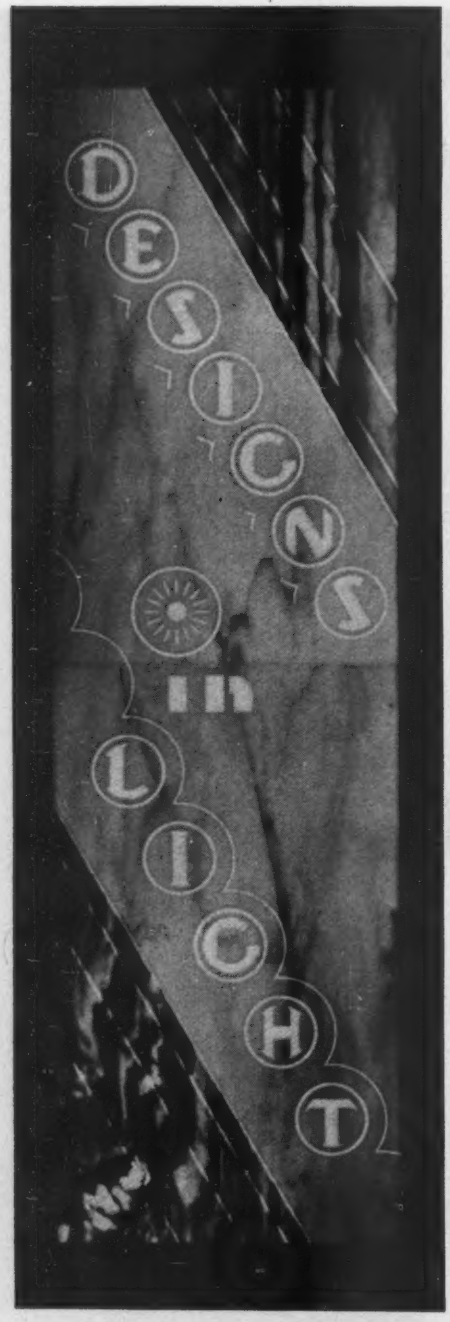
Lumar, the trade name of marble made luminous by man, is a product of the Vermont Marble Company, and is the climax of efforts on the part of that concern to familiarize itself with the physical characteristics of the stone so as to adapt it to meet still better the wide uses to which it is put. This has entailed intensive laboratory investigation, carried on for the company by Prof. George W. Bain of the Department of Geology of Amherst College. The Mellon Institute at Pittsburgh and the Nela Park Division of the General Electric Company at Cleveland also have participated. A scientific advance of so marked a character is inevitably the outcome of cumulative steps.

From the studies financed by it, the Vermont Marble Company learned much about the crystalline structure of the stone. The microscope disclosed physical facts that may have been surmised but were not previously evaluated. Magnification revealed that the arrangement of the interlocked crystals was by no means uniform in all marbles: that it differed in materials originating in different deposits. Likewise it was found that the sizes of the prevalent grains varied in a more or less pronounced degree, depending upon the bed from which the stone was taken. Finally, certain marbles are notable because of the distinctive disposition of the axes of the calcite crystals in relation to one another—this being generally symmetrical.

Close observation with the aid of a microscope brought out the fact that a calcite crystal is far better able to resist the attack of the atmosphere or weather if its basal face is exposed at the surface of the marble. Therefore, if the material be cut so as to keep the superficial crystals in that relation to the atmosphere—with the vertical crystallographic axes perpendicular to the surface of the stone—it will be far less likely to undergo impairment by weathering. Again, marble is said to have more uniform and narrower openings between its constituent crystals than have other commercially much used stones. Under the searching eye of the microscope, and with permeability apparatus, it was determined that the passages offered by those openings have a direct bearing upon the measure of penetration of moisture into the marble and that the cutting of the stone could be

SOURCE OF STONE

A scene in the depths of a Vermont marble quarry, 300 feet underground, where the stepped surface marks the successive lifts of removed blocks. Near the left center is to be seen one of the massive concrete struts which are placed at intervals to support the side walls of the quarry as depth is attained.



A LUMAR SIGN

This illuminated panel is in the lighting room of the General Electric Company plant at Nela Park, Ohio. It is made of three varieties of marble. Carving and lettering of the surface of Lumar is done either by etching or by engraving with the aid of the sand blast.

done in a way either to increase or to diminish the admission of moisture and its advance into and even through a block of given dimensions. Through this line of research the Vermont Marble Company was able to obtain scientific data on which to base improved processing methods, thus making it possible for that firm to benefit its customers. Even so, these advances did not materially augment the volume of business, nor did they serve to widen the established uses to which marble has long been put. From a commercial point of view, the desire was to find new applications that would set the stone apart from other materials and be the outgrowth of its peculiar characteristics. Lumar is the answer.

The Vermont Marble Company quarries, processes, and markets more than 50 different kinds of marble, and it produces the material not only in Vermont but also in Colorado, Alaska, and Montana. These various stones are superficially distinguished by color, marking, and texture. It was to Professor Bain that the company assigned the task of selecting the particular marble which, because of its crystalline structure—its particles of transparent calcite with their associate air films—could be utilized for the purpose of transmitting light. Success was first won by processing slabs of what is known as Yule Golden Vein marble, which is obtained from a deposit at Marble, Colo. The crystals of this stone, which was carefully chosen from certain parts of the quarry, are said to have a light-transmitting capacity that is nearly equal to that of glass and a light-diffusing power greater than that of any other competing product.

The production of Lumar calls for marble possessing three essential qualities: The material must cause an extreme diffusion of the light rays reaching it from its artificially illumined face; it must promote to a high degree the transmission of the light rays; and the constituent crystals must sparkle when illumined by the penetrating light. These desirable characteristics can be had in combination only if the crystalline fabric is right, if the air-film openings are of the required minute narrowness, and if the stone be sawed into slabs with careful regard to the "grain-fabric pattern." The width of the openings may be modified by the angle of cutting during the fabrication of the slabs, just as the opening at the end of a straw will depend upon whether the latter is cut at right angles to the axis or slantingly.

According to Professor Bain, the noticeably high degree of diffusion in Lumar is due to the twofold action of reflection and refraction of the light rays at the contacts between the myriads of minute grains or crystals. The best results have been obtained with marbles composed of calcite grains that are separated by air films having widths varying from 2.5 to 5.0 millimicrons—the larger figure being about two ten-millionths of an inch. Those tenuous air films cause a light ray to be reflected back into the calcite crystal when the angle of incidence—the angle of striking—exceeds the critical angle, which is 37 degrees for the ordinary ray and 42.5 for the extraordinary ray. Therefore, whenever the angle between the light ray and the surface of the crystal is 53 degrees or less, then the ordinary ray is reflected back into the grain; but if the angle be 47.5 or less then both rays are reflected. Because of this, most rays undergo repeated internal reflection in different directions, depending upon the form of the grain of calcite. The transmitted light reaches the surface opposite the source by an exceedingly circuitous path and emerges from the slab of Lumar remote from the point where the ray originally entered. However, the extraordinary ray takes a more direct route and is absorbed less. By reason of this high degree of diffusion the source of the illumination is invisible. There is no "spottiness," illumination is general, and the light seems to issue uniformly from the stone itself rather than from a lamp behind it. The sparkle, which adds so much to the beauty of luminous marble, is due to the multiple reflections at the contacts of the calcite particles; and this zigzagging back and forth of the light ray is just what takes place in a diamond that scintillates because of internal reflections at the facets of that cut gem.

Marble that best serves the requirements of Lumar must have its calcite grains arranged at the light-receiving plane of the sawed block so that there will be a minimum concentration at that surface of the vertical axes of the calcite particles. Next, the air-film openings must be of appropriate width for the admission of the extraordinary rays of light—those of 42.5 degrees—which trace a more direct path through the stone than do the ordinary rays. The latter, because of their much more frequently repeated reflections, are quickly dimmed and absorbed by the calcite particles. In the case of the extraordinary rays, however, the absorption is far lower, the successive reflections are fewer, and the light emitted finally at the outer surface of the slab is correspondingly stronger. In short, though the path of the extraordinary ray is more direct, yet its points of reflection at the facets of the calcite granules that flank the air films are numerous enough to cause the diffusion which illumines the interior mass of the marble. It should be apparent that the blocks of marble from which Lumar is produced are selected and sawed with care so that the crystals and the air films will give maximum effectiveness to the extraordinary rays.

Reference to the ordinary and the extraordinary rays of light may possibly lead the reader to believe that some special type of illuminant is essential to make Lumar effective. Such is not the case. Ordinary electric bulbs are employed in Lumar installations, the wattage depending upon what its designer may consider necessary to produce either a dull or a bright glow. Maintenance of the general intensity of the illumination is important to assure uniform diffusion; and it will be readily understood that bulbs of high wattages must be used wherever exterior lighting is to be relatively brilliant. Conversely, if the external light is to be dim, then the power of the bulbs behind the Lumar may be lowered proportionately and yet bring out all the beauty of the internal characteristics of the marble by a soft diffusion of the transmitted rays. It is claimed that the light-diffusing properties of the material are equal to and even

superior to those of diffusing glasses.

In the beginning of this remarkable development in the marble industry the stone from the Colorado quarry was deemed best because of its structural characteristics. But now, varieties from Vermont are utilized because they give certain very desirable color effects, and color is one of the dominant demands in present-day decorative schemes. The slabs are marketed in thicknesses of ½ and ¾ inch. Panels ½-inch thick may be had with a total area of about 12 square feet, the maximum dimension being 4 feet, while the largest of the ¾-inch panels produced has an area of about 25 square feet, the longest dimension being 5 linear feet. Five varieties of Lumar panels are now available, and they are distinguished, respectively, by reason of their markings and coloring. They can be had with finely lined striations and golden-brown markings; a field of deep, creamy yellow in which green clouds seem to float; sunset colors crossed by bands of soft green; bands and bars of alternating green and yellow; and golden slabs with combinations of light and dark wavy effects and with crystal-clear areas of quartz.

The nature of the coloring matter and not the presence of color determines whether or not a particular kind of marble is suitable for Lumar panels. As explained by Professor Bain: "Most red and orange marbles owe their color to light reflected from the surface of opaque limonite and hematite particles. This variety transmits little light and has limited use. A few light red and yellow marbles receive their color from yellowish mica, chlorite, amphibole, and quartz particles, and make excellent luminous marble. Mineral composition of the coloring agents is an exceedingly important property." To this geologist was assigned the task of selecting different marbles for their inherent light-transmitting qualities; and to the Mellon Institute was given the problem of devising processing means that would serve to reduce the width of the air-film openings in those where they are too large naturally for the most effective transmission of the extraordinary rays of light which play so preëminent a part in making translucent a stone that normally is opaque.

After the pneumatic rock drill has done its work of freeing a block of marble from its age-old bed, then it is moved to the mill to be sawed into the required slabs. These are cut with gangs of drawsaws that use sand to assist the operation. Then they are rubbed to the desired thickness on rubbing beds by means of sand, while abrasive bricks and felts give the honed or polished surfaces. The range of marbles that can be employed for the production of Lumar slabs has been increased through the disclosure that it is possible to cut down the intergranular space of a given variety by recourse to filling materials, thus making it suitable for the effectual transmission of the extraordinary rays while incidentally reducing the ordinary rays of light.

A MARBLE ALTAR

The reredos of this beautiful altar in the Church of St. Francis of Assisi in New York, N.Y., is composed of etched panels of marble through which light is transmitted. Lumar is available in slabs, ½ and ¾ inch thick, having a maximum area of approximately 25 square feet. It comes in five varieties which differ widely in the matter of color and markings.

The external surface of a slab of Lumar may be etched or engraved with the aid of the sand blast in any design or pattern, thus creating an overlay effect of a lacy character. Some extremely beautiful results can be obtained in this way. The stone has already found many and varied applications. It may be used for pilasters, columns, posts, spandrels, frieze courses, window valances, pylons, beams, wall and ceiling panels, free-standing screens, counters, show cases, table tops, clock faces, mirror-lighting panels, and for lighting fixtures of the trough, cove, or cornice types, and has been employed effectively in the construction of store fronts, theaters, hotels, restaurants, banks, churches, etc. It has greatly enriched the decorative potentialities of architecture.

In the days of ancient Greece, her sculptors and architects obtained polychrome effects by recourse to staining. The result was but an imperfect attempt to heighten or to improve upon nature's handiwork, and was inevitably artificial. Now, on the other hand, the otherwise hidden beauties in the depth of the marble are rendered visible; and a slab of Lumar, instead of presenting a 2-dimensional surface, has the added revealing charm of a third dimension, thanks to the research man and to the efforts of a great industrial organization to amplify, to diversify, and to improve its products.

DRILLING GROUT HOLES

A view at the east end, showing Calyx core drills putting down holes for the grout curtain that is being placed in the foundation rock along the upstream side of the dam. Seven gasoline-driven drills are employed for this purpose, five of them being G-33 models that have seen much service on other Colorado River dams. The two other units are modern H-3 machines. In silt-covered areas, 3-inch casing is set on bedrock to keep holes open in that soft material. Drilling in the foundation rock is done with "calyxite," or chilled shot. Many of the holes are redrilled after a first grouting, and for this work a special fishtail bit of hardened cast iron was designed on the job. In addition to putting down the grout holes, these drills were extensively used for the exploratory foundation drilling that provided complete information about subsurface conditions before the work of reconstruction was begun.

THE DAM BEFORE AND DURING RECONSTRUCTION

A view from the east bank, showing the structure as it appeared on June 29, 1937. The entire section left of the spillway is a part of the original masonry dam that was erected nearly half a century ago, while the remaining length visible is the hollow concrete section that was built in 1915. Surmounting the dam at several points are piers that formerly supported gates on the crest. The gates and the missing piers were swept away by floods, the greatest of which occurred in 1935. On the opposite page is a picture taken from the west side of the river showing a portion of the gravity section that was reinforced and heightened with concrete applied after one course of the granite masonry exterior had been removed. The diversion slot, through which the river will run while operations are being conducted in the hollow section of the dam, is seen partly cut through the structure towards the left end where there is a gap in the concrete. The concrete mixing plant is at the right end.

AS THE fourth construction phase of its program to bring the Colorado River in Texas under control, the Lower Colorado River Authority is rebuilding one of America's most famous dams, the Austin Dam at Austin, Tex. This structure spans the river about 24 miles downstream from Marshall Ford Dam, which is now well along towards completion. Above Marshall Ford are Inks and Buchanan dams, the last named of which was described in our November, 1936, issue. Collectively, these structures, when completed, are intended to reduce to relatively harmless proportions the periodic floods that have been causing property damage estimated at $4,000,000 annually. They will also provide a dependable supply of water for irrigating fertile land in the lower portion of the river valley and for generating hydro-electric power.

Although perhaps few of the younger generation of engineers ever heard of it, the Austin Dam is well known among their elders in the profession. When it was built, nearly half a century ago, it was considered a very daring feat in the engineering and construction field. No previous effort had been made to throw a gravity-type masonry barrier across a stream of the size and with the erratic flow characteristics of the Colorado River. That stream drains an area of some 50,000 square miles and, although normally placid, is subject to sharp rises which swell it to bank-full proportions almost without warning.

Many persons thought that the construction of the Austin Dam was a foolhardy undertaking, and subsequent happenings, if considered only by themselves, would seem to indicate that they were right. The history of the dam is a chronicle of misfortune. During the 46 years of its existence, it has fully served its intended purpose for only seven years. Several times its original cost has been expended in efforts to make it strong enough to withstand the river's rampages. Another sizable sum has gone into a succession of investigations and reports which were designed to determine how to give the structure the desired stability.

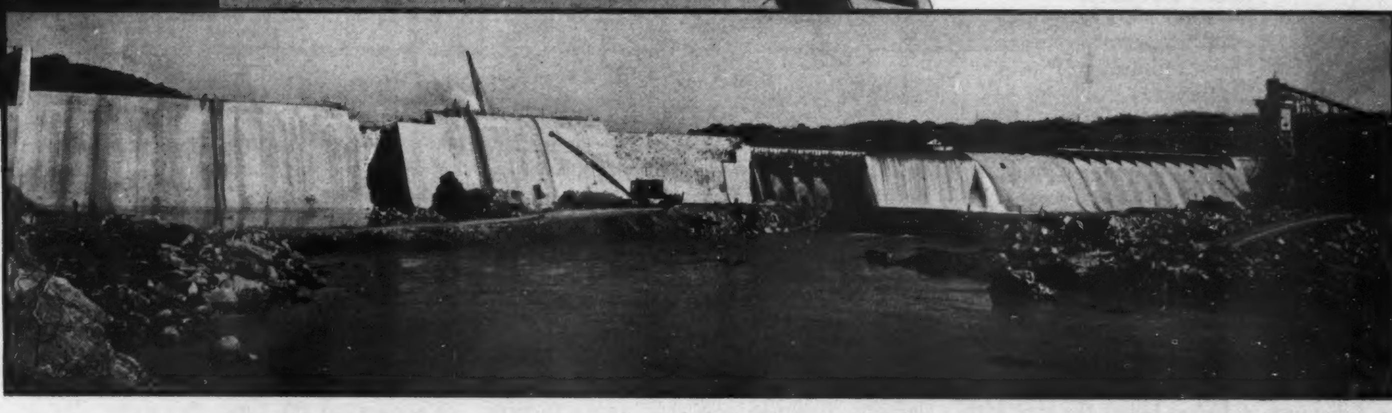
In view of its unfortunate past, Austin Dam would appear to be something for engineers to eschew. However, they are going ahead, rebuilding it with full confidence that they will transform it into an enduring structure. The explanation for this confidence is very simple. The art of constructing dams has progressed a long way since the original Austin Dam was built. It is now evident that the underlying cause of

Reconstructing the Austin Dam

C. H. Vivian

REMOVING OLD GRANITE FACING

Prior to pouring a new and thicker face of concrete upon the gravity section, the exterior course of the original granite-block masonry was removed. As no explosives could be used, this work was done with paving breakers and bars, and by means of the plug-and-feather method of breaking stone.



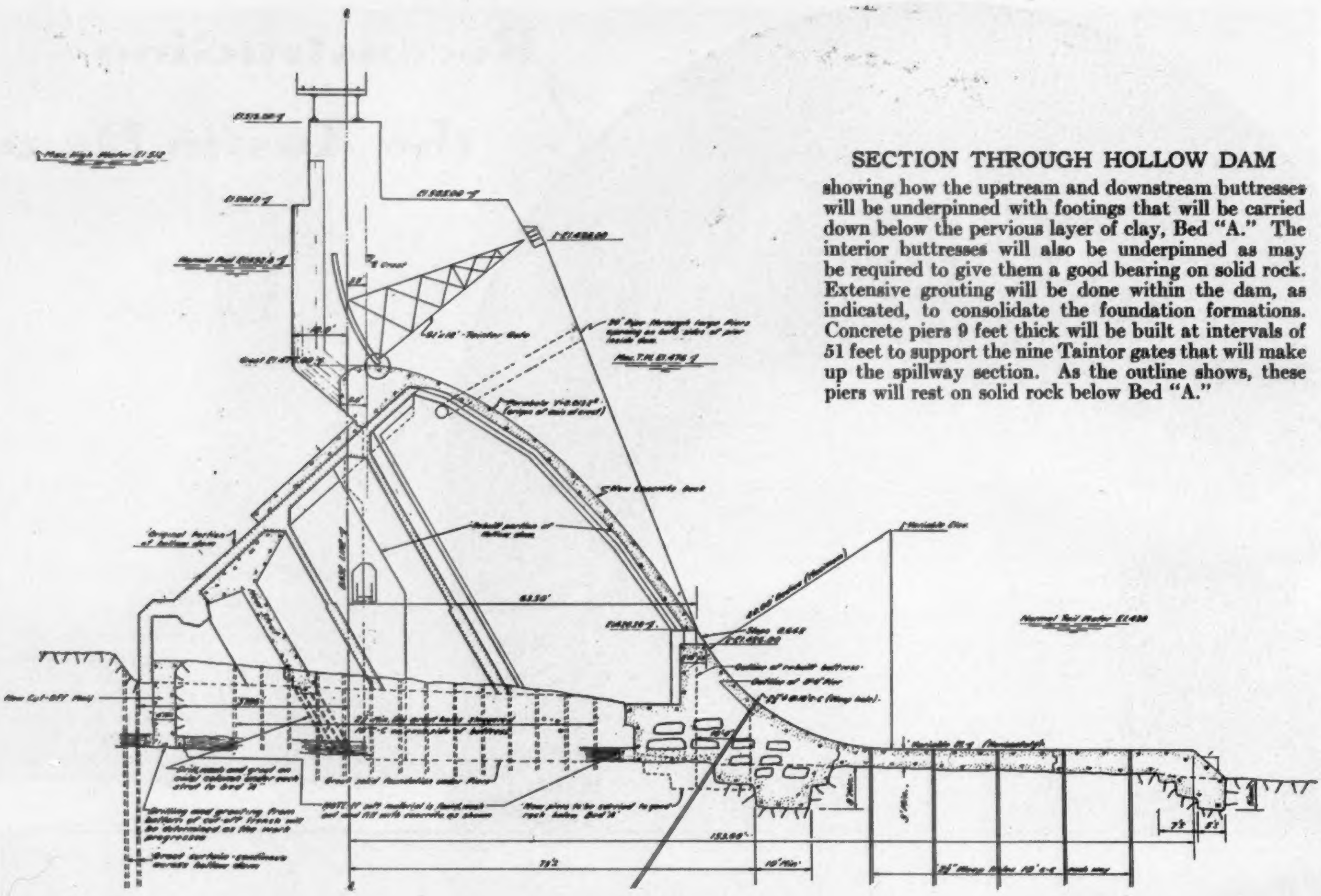
all the trouble was the failure of the designers to make a thorough investigation of the river bottom. Had they done so, it would have been obvious to them that no dam on that particular site could long remain unimpaired unless its roots were sunk deep enough to rest upon solid, unyielding material. Instead, they either did not realize the importance of careful subsurface exploration, or they chose to ignore it and to trust to providence to keep the structure intact.

The current reconstruction work is based upon a comprehensive and painstaking study of the underlying formations. The geological conditions at the dam site are well known to the present engineers and constructors, and they are taking suitable steps to correct the mistakes previously made. Moreover, the rebuilt dam will not be called upon to withstand floods comparable in severity to those that passed over the old structure every few years. The combined storage capacity of man-made reservoirs upstream is ample to flatten out the flow of the river during high-water periods and to keep the crest of the floods well below the danger point.

Before giving a more complete account of the work now underway, it will be of interest to trace the checkered history of the Austin Dam. As early as 1839, the possibility of developing water power on the Colorado River at Austin was recognized. During the next 40 years, four different proposals were made for the building of a dam at that location; but none of them was approved. In 1889, John McDonald ran for mayor of Austin as the sponsor of a plan for a dam that had been originated by A. P. Woodridge during the previous year. McDonald was elected, together with a board of aldermen that favored the enterprise.

In February, 1890, Joseph P. Frizell, a Boston hydraulic engineer, was engaged to make an investigation of the project, and on March 26 he recommended the construction of a masonry dam 60 feet high. He did not have the benefit of recorded river-flow data. The oldest inhabitant that could be found estimated that the greatest flood within his memory was a rise of 45 feet above the normal water level. Frizell calculated this to correspond to a flow of 250,000 second-feet, which would mean a depth of 16 feet on the crest of the proposed dam.

The purpose of the dam was to develop power for lighting Austin, for pumping its water supply, and for propelling its street cars. The scheme outlined by Frizell was approved by John Bogart, a New York consulting engineer. Bernard Corrigan obtained the contract for building the dam on a bid of $501,150, and began excavating in the river bed on November 5, 1890. The last stone was laid on May 2, 1893. The site of the dam was two miles upstream



SECTION THROUGH HOLLOW DAM

showing how the upstream and downstream buttresses will be underpinned with footings that will be carried down below the pervious layer of clay, Bed "A." The interior buttresses will also be underpinned as may be required to give them a good bearing on solid rock. Extensive grouting will be done within the dam, as indicated, to consolidate the foundation formations. Concrete piers 9 feet thick will be built at intervals of 51 feet to support the nine Taintor gates that will make up the spillway section. As the outline shows, these piers will rest on solid rock below Bed "A."

from the city. At that point the river channel is confined between bluffs having respective heights on the east and west sides of 60 and 125 feet. The crest of the dam was 60 feet above low water and 68 feet above the lowest part of the foundation. The width at the base was 66 feet. The upstream face was vertical. The top was in the form of a curve with a radius of 20 feet. The downstream face had a batter of 1 in 8 for a distance of 40 feet below the top, with a toe extending from its foot on a curve with a 31-foot radius. The length of the structure was 1,275 feet, of which 1,125 feet was spillway. The exterior was of cut red granite obtained 80 miles from the site. Some of the blocks had a content of as much as 90 cubic feet. They were handled by a cableway that spanned the river and were placed by a stiff-leg derrick. These blocks were laid with full mortar joints, and care was taken to make the upstream face watertight. The interior was composed of limestone rubble, and the spaces between blocks were filled with concrete. The dam contained about 95,000 cubic yards of masonry.

In the Austin area, the ground surface beneath the mantle of top soil is classed geologically as the Edwards limestone formation. This dips gently toward the coast. The Edwards formation is made up chiefly of limestone layers separated by strata of marl. Some of the limestone members are of uniform hardness: others have alternating hard and soft portions. In some cases the latter have been dissolved by underground circulating water, leading to honeycombing.

The river bed at the dam site was covered with a layer of silt several feet thick, and immediately below this deposit was a hard, sound limestone layer. The original builders, according to the records they left, believed that this hard bedrock was of indefinite thickness and that any structure reared upon it would stand firmly. Subsequent events have disclosed, however, that this surficial layer is only about 8 feet thick and that it is underlain by a bed of clay approximately 2 feet thick. This clay stratum, which the current constructors refer to as Bed "A," is pervious. It has been established beyond doubt that water passing beneath the dam through this layer has been the major cause of all past troubles.

It is also a well-known fact now that the Balcones Fault, a surface breach extending for several hundred miles, crosses the river just above the dam site. In some bygone age there was a major displacement as a result of which relative layers of rock on the downside of the fault are several hundred feet lower, stratigraphically speaking, than the corresponding members on the upside of the fault. The dam site itself is within the zone of secondary minor faults. Because of the ruptures in the strata, circulating ground water has easy access to the surface, and just upstream from the dam there are springs the aggregate flow of which is such as to materially increase the volume of the river.

On May 30, 1893, less than a month after the dam proper had been finished, water began passing underneath the structure on the east side and flowing into the excavation which was then being made a short distance downstream for the power house. Although the fact was either not recognized or ignored at the time, this water was undoubtedly flowing through the Bed "A" just mentioned. In the area affected, it washed away enough of the soft clay to permit the overlying limestone layer to settle. This, in turn, allowed a portion of the surmounting headgate masonry to subside. In addition, a part of the power-house foundation wall was similarly undermined, and it overturned.

As a corrective effort, a cofferdam was constructed just upstream of the dam. It was 200 feet long, 7 feet wide, and 70 feet deep, and spanned the section of the stream bed beneath which the water was flowing. The headgate masonry was rebuilt, and that portion of the dam immediately east of the penstocks was backed up with a concrete wall 112 feet long and having a maximum width of 8 feet. In excavating for this wall, alternate layers of hard and soft limestone were encountered. It was demonstrated in the course of erection that water was running underneath the layer of rock on which the base of the wall rested;

but this fact apparently went unheeded.

In a further attempt to strengthen the structure, a tunnel 6 feet square and 60 feet long was driven under the headgate bulkhead masonry and filled with concrete. After all these steps had been taken, excavating for the power house was continued; but the contractor found it impossible to stop the flow of water and ceased work. A new contractor took over and disposed of the problem by the rather ingenious expedient of constructing a concrete chamber to impound the water, thence discharging it through one of the power-house walls by way of a 10-inch pipe. Two years later, the records show, this pipe was discharging 4.6 second-feet of water.

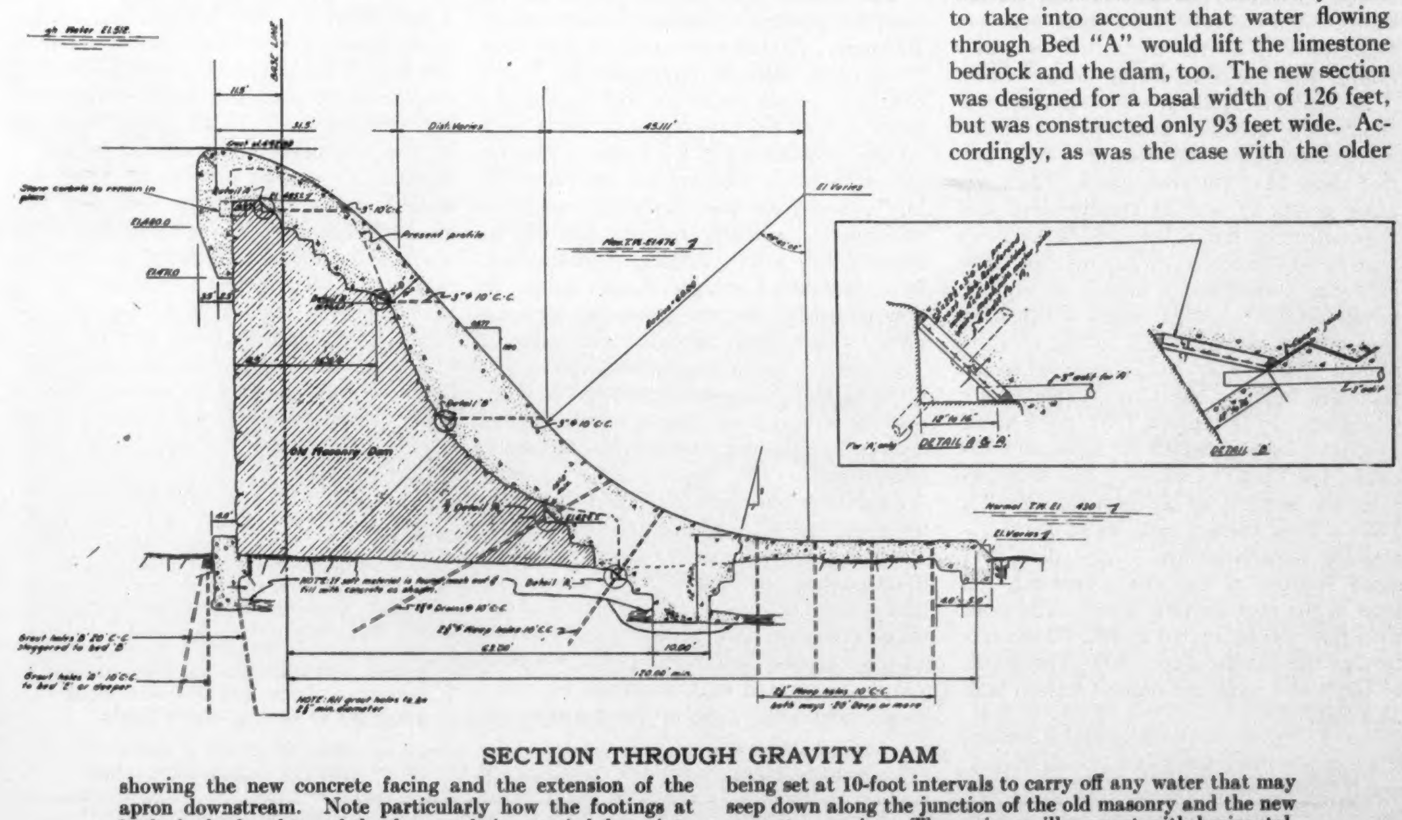
The toe of the dam did not extend far enough downstream to give the water passing over the structure a horizontal direction during flood periods. Instead, much of it fell in the pool beyond the toe line, and its force was sufficient to tear away some of the surface rock from the stream bed and, consequently, to undermine the toe. That this erosion was taking place was proved in 1897 when a fisherman ran his pole underneath the toe for a distance of 6 feet. In 1899 leaks were discovered twice near the east end of the dam, and in both instances hay and bagged clay were used in an effort to stop them.

On April 7, 1900, during a flood, when the water level reached a height of 11 feet above the crest of the dam, the structure gave way at a point 300 feet from its eastern end, and two sections, each 250 feet long, were moved downstream more than 70 feet. They remained upright until some time later, when they were broken up and disappeared. Following this disaster, numerous investigations were made, including soundings by Prof. T. U. Taylor of the University of Texas, that showed that several feet of the underlying rock had been washed out along with the two sections of the dam. The first exploration of the subsurface of any consequence consisted of 27 borings made by Walter G. Kirkpatrick in 1908. They disclosed alternate layers of moderately hard limestone and adobe, the latter containing cavities.

Reconstruction was undertaken in 1911 by a corporation called the City Water Power Company, which issued bonds to finance the work. Operations were carried on by force account until June, 1912, when a contract was entered into with the W. P. Carmichael Company of St. Louis. Floods during 1913 and 1914, reaching a maximum flow of 220,000 second-feet, greatly hindered progress and damaged partly finished structures. Because of these delays the work was not completed until 1915.

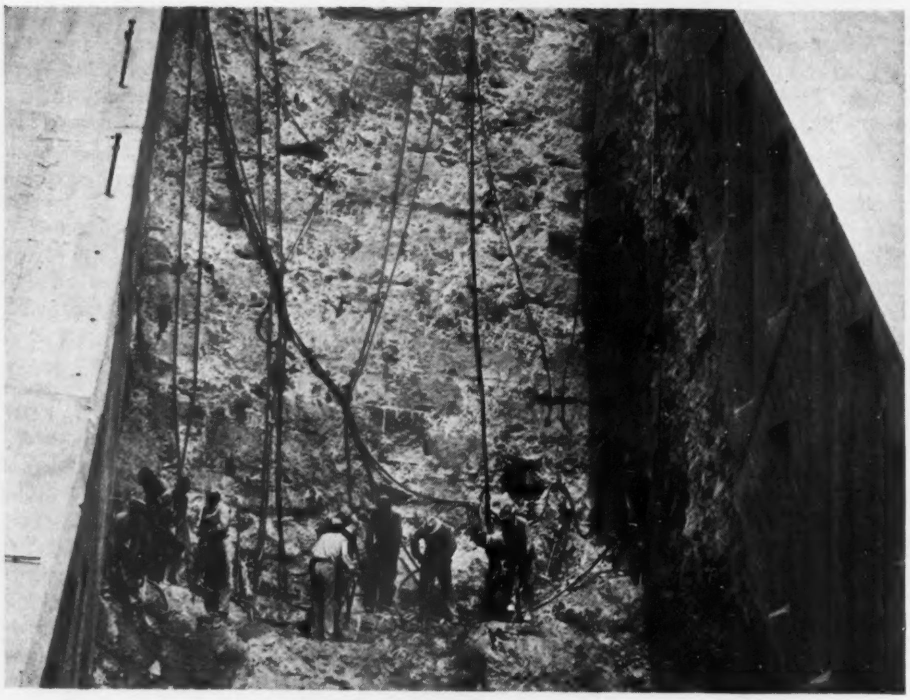
As rebuilt, the dam was 1,535 feet long and made up, from west to east, of a 470-foot section of old masonry, of 560 feet of new concrete, of 61 feet of old masonry, of 144 feet of bulkheads, and of 300 feet of core wall that extended into the east bank. The core wall varied in height from 75 to 90 feet and was carried deeper into the ground than the foundations of the dam proper. The new concrete section had a height of only 51 feet above low water, or 9 feet lower than the flanking sections of old masonry. Crest gates surmounted both and extended to a height of 15 feet above the new section and of 6 feet above the old sections, their tops having a uniform elevation of 66 feet above low water. These gates were designed to open automatically when the water level reached 65½ feet and to close automatically when it fell to 64 feet. There were 28 large and 26 small gates having an aggregate length of 1,091 feet. It was calculated that, with the river flowing 200,000 second-feet, the water would be 18 feet deep over the new section and 9 feet over the old sections which had previously withstood a depth of 11 feet.

The new part of the dam was of hollow section, as illustrated in an accompanying drawing. It was strengthened by longitudinal and transverse buttresses on 20-foot centers. The transverse internal walls extended above the deck, and on top of them were laid girders that carried tracks for a railroad crane. Similar walls were erected on top of the old masonry sections, being tied to them by means of vertical reinforcing bars. There was no base under the hollow section, it having been omitted on the theory that the uplifting effect of any water that might pass under the structure would thus be minimized. This theory failed to take into account that water flowing through Bed "A" would lift the limestone bedrock and the dam, too. The new section was designed for a basal width of 126 feet, but was constructed only 93 feet wide. Accordingly, as was the case with the older



SECTION THROUGH GRAVITY DAM

showing the new concrete facing and the extension of the apron downstream. Note particularly how the footings at both the heel and toe of the dam are being carried down into the foundation rock below the pervious Bed "A." These cut-offs, combined with extensive grouting of the subsurface formations, are calculated to prevent water from flowing under the dam. Weep or drainage holes are being drilled through the dam and the apron at the locations shown. At four levels in the concrete, horizontal drainage pipes are being set at 10-foot intervals to carry off any water that may seep down along the junction of the old masonry and the new concrete covering. These pipes will connect with horizontal, enclosed channels in the interior of the dam which are designed to collect the water. Individual sketches at the right illustrate how these channels are formed by setting precast concrete slabs at the prescribed levels before pouring the concrete facing. The crest is being raised to a point 2.8 feet above its former level.



CUTTING DIVERSION SLOT

This opening in the masonry dam was made to permit the river to pass through while the hollow dam section is in progress of rebuilding. As no explosives could be used, the slot was literally gouged out, a little at a time, with CC-45 paving breakers. This picture shows the interior of the dam, which consists of limestone blocks and concrete. Note that the new concrete facing on this section of the dam was poured on each side of the diversion slot before it was finally cut through.

structure, the toe did not reach far enough downstream to prevent the river bed from being torn up by the impact of the water falling over the dam during flood periods.

In September, 1915, with the dam virtually completed and awaiting only official acceptance by the city council, a flood carried away 24 of the crest gates. The operating company was in receivership, and the contractor, having spent $250,000 more than he was to receive, was bankrupt. The city was consequently unable to enforce reconstruction. Sixteen years of litigation then ensued, during which an organization named Austin Dam, Inc., succeeded to the franchise held by the City Water Power Company. In December, 1931, the Federal District Court approved an agreement between the litigants whereby the dam became the property of the city. On June 15, 1935, a flood carried away most of the remaining superstructure of the dam and small sections of the crest, lowering the level of the pool above it 3 feet. The peak river flow was estimated at 400,000 second-feet, or the highest since 1869. The depth of the water over the hollow section was 24.5 feet.

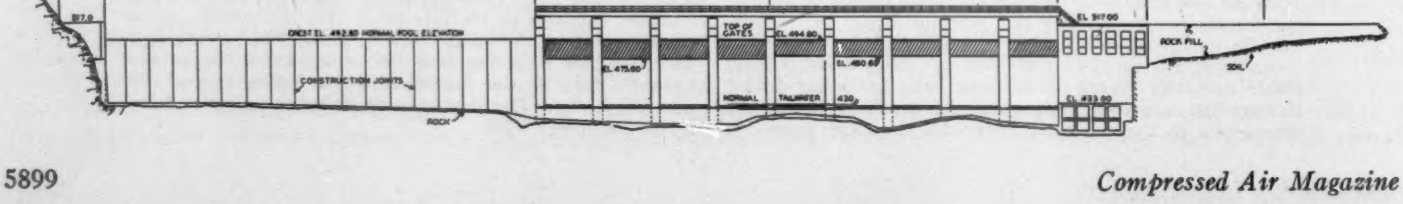
The Lower Colorado River Authority has been granted a lease on the dam site for 30 years. At the expiration of that time the City of Austin can purchase the rebuilt dam and power house at cost, minus depreciation at the rate of 1 per cent a year on the structures and 3 per cent a year on the machinery. The city has contracted to buy power from the Authority, which is constructing a double transmission line to connect the power houses at Buchanan, Inks, Marshall Ford, and Austin dams. It now generates its own power in a steam plant, which it has agreed not to enlarge. The power requirements of Austin are growing at the rate of 7 per cent a year, and the prospects are that it will be buying a considerable block of current within a few years.

As an alternative to rebuilding the existing dam, the Authority considered a new structure a short distance downstream; but it abandoned the idea when it was found that it would involve an estimated additional expenditure of $200,000. The prospective cost of reconstruction is $2,500,000, and it is expected that work will be completed next fall. One of the benefits to Austin will be the creation of a scenic lake that will afford many of its people recreation. The dam will back the water up 25 miles to Marshall Ford Dam. Although the present structure formed a body of water almost as great, its attractiveness and usefulness have been lessened by the accumulation of silt that has filled most of the reservoir space. The three upstream dams will prevent extensive silting in the future. The water stored in them will also insure a sustained flow for the generation of power at Austin Dam which, consequently, will be of greater utility than ever before.

The current operations might aptly be called construction surgery. Virtually all the existing dam will be retained; but it will be bolstered and reinforced by extensive new work. The foundations will be carried below the trouble-making Bed "A," and the toe will be lengthened so that even heavy flows of water over the structure will fall wholly upon a concrete apron instead of upon the river bed. Finally, intensive grouting of the underlying formations will consolidate and strengthen weak layers and render them impervious.

The first work was done at the western end of the dam, where a better bond with the abutting cliff was obtained. A total of 2,700 cubic yards of rock was excavated with Jackhamers, and the upper part of the dam extended into the cliff by the construction of a concrete wall 10 feet thick and rising to a point 32 feet above the top of the masonry. Joining this wall and forming a right angle is a wall that was built for the protection of the cliff just downstream from the dam. This will prevent any detrimental erosion of the abutment by the water passing over the dam. To fill up any openings in the abutment rock and to render it watertight, a large number of holes was drilled in the cliff at the dam line and grouted. These holes were spread out in the shape of a fan and penetrated the rock for distances of 40 to 60 feet. They were drilled with Ingersoll-Rand X-71 drifters on Type FM-2 wagon mountings.

The accompanying cross-sectional drawings indicate the general scheme that is being followed in both the hollow and the



DOWNSTREAM ELEVATION

The reconstructed dam will have an over-all length of approximately 1,520 feet made up of the different sections indicated. The structure has been designed to withstand safely a flow of 200,000 second-feet. Although greater volumes of water have been experienced in the past, the three upstream dams—Buchanan, Inks, and Marshall Ford—will serve to control future floods.

old-masonry sections. In the masonry section where work was first concentrated, one course of granite blocks has been removed from the downstream face and a new face is being formed of reinforced concrete varying in thickness from 7 to 10 feet. The crest is being raised 2.8 feet above its former level—that is, to Elevation 492.80. The concrete facing is also being extended down the upstream side to a point approximately 20 feet below the top, thus materially increasing the thickness of the upper part of the structure.

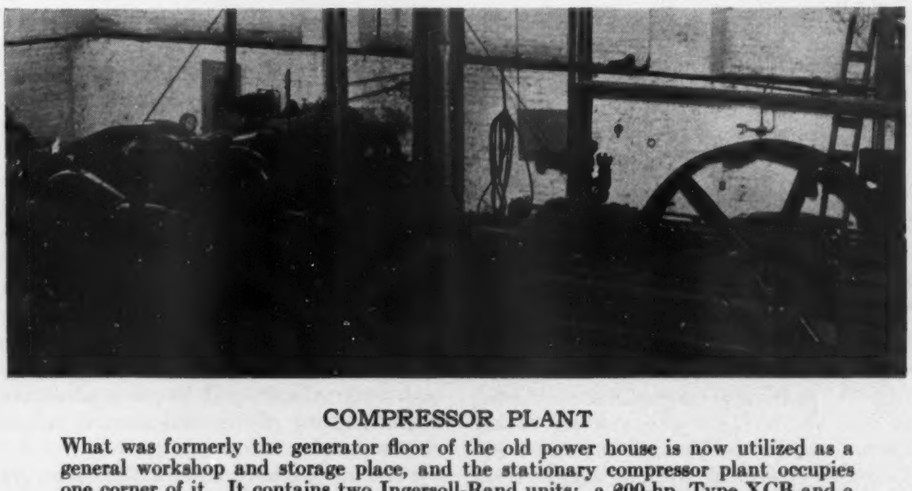
The method of obtaining foundation bearings below the offending Bed "A" is clearly shown in one of the drawings. Just downstream from the toe of the masonry structure a keyway is cut through the limestone layer that forms the river bed and through Bed "A" down to solid material. The trench is then filled with concrete to a minimum thickness of 12 feet. This concrete key is referred to on the job as the "bucket." It has a minimum width of 10 feet, and its base is made considerably wider by excavating Bed "A" about 2 feet in an upstream direction and 5 or more feet in a downstream direction, thereby locking the concrete cut-off wedge securely. A concrete apron, with a minimum thickness of 3 feet, will be carried downstream from this "bucket" for a distance of approximately 45 feet. Its downstream end will be firmly anchored to the limestone layer upon which it will rest by a keyway 5 feet wide and reaching a minimum of 5 feet into the rock.

A CROSS-RIVER VIEW

A picture taken from the top of the west abutment and looking east along the crest of the dam. The opening in the mid-foreground is the diversion slot. At its upstream end is being driven steel sheet piling for a cofferdam within which to place the upstream cut-off wall at the base of that part of the dam preparatory to cutting the slot through. The accumulation of silt in the reservoir is visible in the left foreground. Although referred to as silt, it consists of 60 per cent clay, 29 per cent silt, and 11 per cent sand. It weighs 102 pounds per cubic foot. In its unconsolidated condition it exerts pressure against the cofferdam when the weight of the heavy dragline used in handling piling is superimposed upon it. To relieve this pressure, the dragline works on a runway made by driving piles to bedrock and capping them with 12x12-inch timbers. The old power house, which will be demolished and replaced by a modern structure, is seen on the opposite shore.

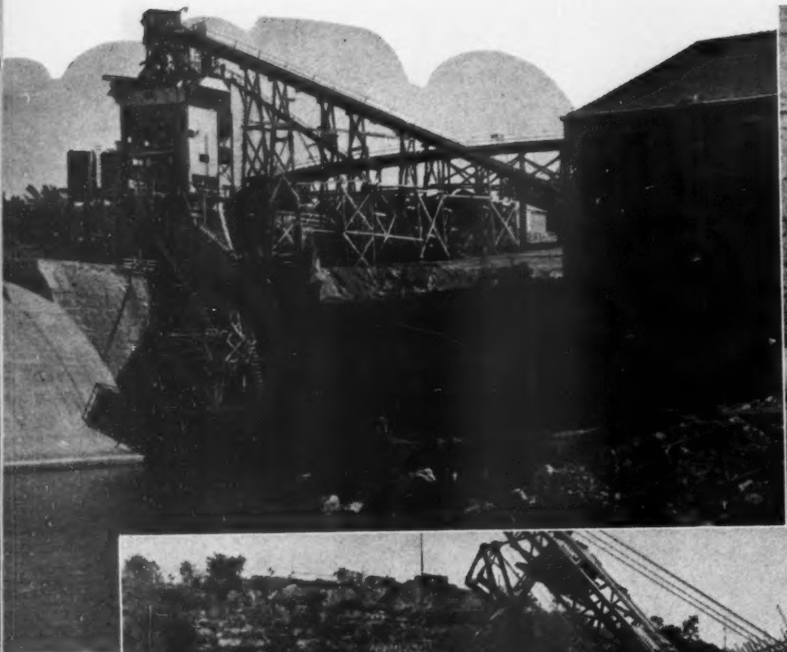
At the base of the upstream face of the dam, a concrete cut-off wall, having a minimum thickness of 4 feet and extending partly under the existing footing, is being carried down through Bed "A" to solid rock. This upstream cut-off wall is being reared within cofferdams, of which six are planned. These are constructed separately by driving interlocking steel sheet piling through the accumulated silt, which is subsequently removed to expose the top of the limestone stratum on which the dam now rests. Within each protecting bulwark, workmen next excavate a trench along and partway under the upstream face, and this is filled with concrete. As soon as a cofferdam has been built it is surrounded with drill holes which extend below Bed "A" and through which grout is introduced. Similarly, holes are drilled in the rock at the bottom of the trench and the underlying ground is thoroughly grouted before concrete is poured. In the case of the hollow section, the upstream cut-off wall and the concrete key at the toe will have dimensions similar to those of the gravity sections, save where conditions, as revealed during construction, may call for modifications. Because it is different in character, however, the hollow section will require much additional attention. As it is necessary to enter the structure to carry on this work, it was scheduled to take place after the release of the head of water upon the dam. This has been accomplished by cutting a diversion slot 25 feet wide through the approximate center of the gravity section at the western end. This opening was completed after the first upstream cofferdam had been rendered safe. It was carried down to Elevation 430, or within 8 feet of the foundation. The bottom of the cut was lined with concrete, and the sides were made watertight and protected from erosion by both guniting and grouting.

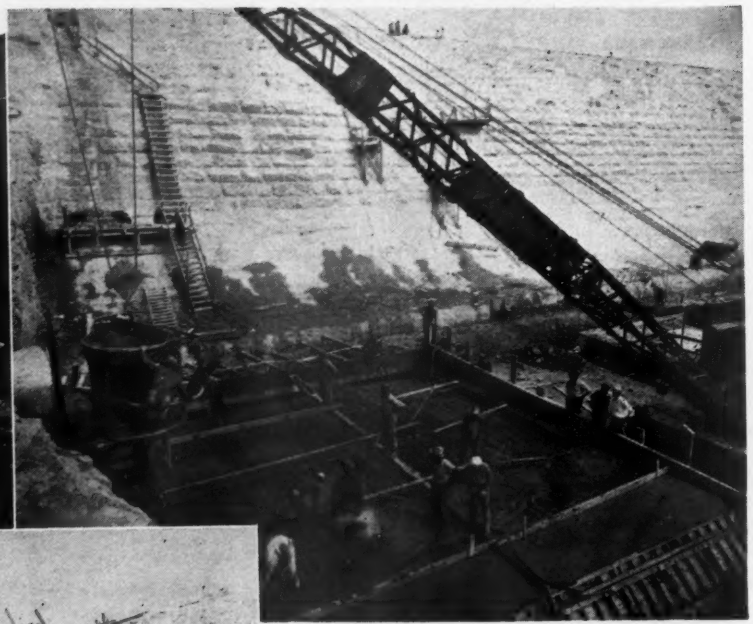
The first work on the hollow section will be to provide a firm support for the base of the downstream face. As an accompanying sketch shows, this face is really a buttress

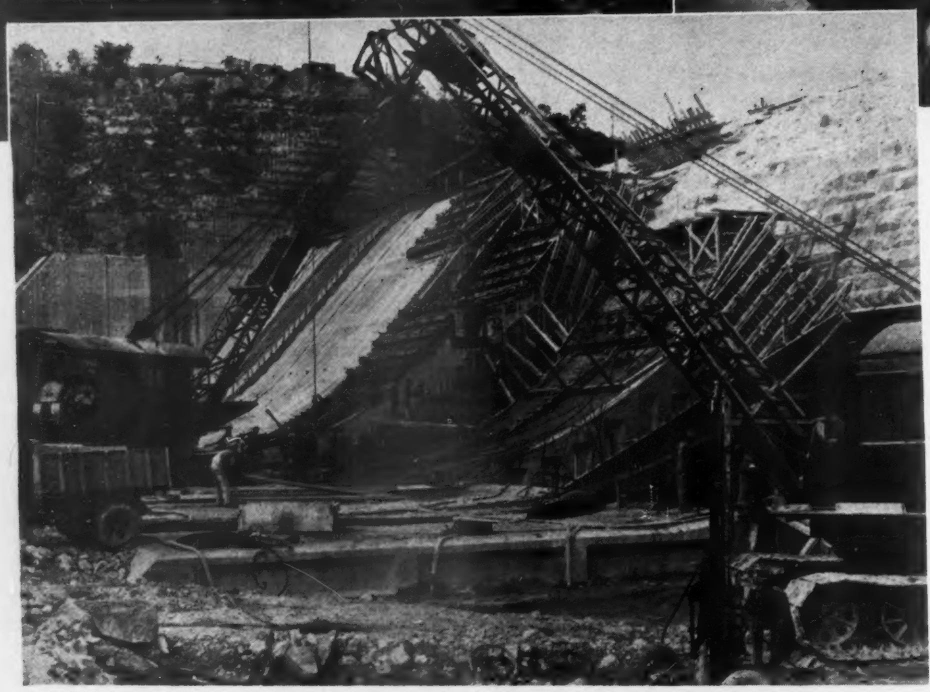


COMPRESSOR PLANT

What was formerly the generator floor of the old power house is now utilized as a general workshop and storage place, and the stationary compressor plant occupies one corner of it. It contains two Ingersoll-Rand units: a 200-hp. Type XCB and a 100-hp. Type XB, having a combined piston displacement of approximately 1,500 cfm. Besides, there are five I-R air-cooled, 2-stage portable compressors of 1,000 cfm. aggregate capacity that are moved about from place to place whenever additional air is needed. The greatest demand for air is for running the 32 paving breakers, eighteen Jackhamers, and six Type X-71 wagon drills which are employed for drilling and demolition work. Other extensive uses are for operating concrete vibrators, No.25 sump pumps for handling casual water, and two impact wrenches that expedite the assembling of concreting forms.







transverse buttresses which will be provided with firm and enduring supports as soon as the downstream face has been underpinned. This will be done by drilling holes through which the clay in Bed "A" can be jetted out with both water and compressed air and replaced with grout. These operations will be started on the downstream side of each pair of buttresses and carried progressively toward the upstream side. Once this is reached, the upstream cut-off wall can be placed across the bay in which work is being conducted. It is planned to dig the trench for this wall and to pour the concrete from within the hollow dam; but if this does not prove to be feasible, a series of cofferdams will be constructed on the upstream side and the work done the same as in the case of the masonry section.

With the cut-off wall in position, the excavation for each Taintor-gate pier can be made and the concrete pier itself poured to as great a height as possible underneath the shell of the dam. Following this, the deck of the hollow dam will be slotted so that the pier can be extended upward. If there is any danger of floods, the sloping deck will be slotted just sufficiently to permit the placing of one lift of concrete, and this procedure will be repeated until the work is completed. This precaution will minimize the chances of water overtopping the structure, filling one of the bays of the dam, and possibly wrecking it. In months when there is no likelihood of extremely high water, the slot will be cut for its entire height and the pier carried upward as fast as practicable.

Prior to the diversion of the river, its flow had been passing over a portion of the hollow section adjoining the junction of the latter and the gravity section. Within this area, the river bed below the dam has been scoured out by the force of the water and there has been considerable undercutting of the toe. Cofferdam No. 3 was put

CONCRETING OPERATIONS

The concrete mixing plant is shown at the upper left. Aggregates are stored in piles behind the old power house at the right, and are elevated by a conveyor belt to bins above the mixers. Cement is blown to the mixing plant through a pipe line extending from an underground steel silo. The plant contains two 2-cubic-yard mixers that can turn out 166 cubic yards of concrete an hour. Concrete is chuted down to a truck-loading station and is hauled in 2-cubic-yard buckets for pouring in the western portion of the dam. That for the east section will be transported by a railroad that is to be run out on top of the dam. A short stretch of the original masonry dam is shown here and, left of it, a part of the hollow structure that was built in 1915. Concreting was started at the west end. The picture at the upper right shows the first block in the apron being poured there. In the lower view concrete is being placed in blocks 25 feet wide and 15 feet high on the downstream face of the old masonry dam. In view of the fact that all the concrete in this area is handled in 2-cubic-yard buckets and has to be transported a considerable distance by trucks, some good pouring progress has been recorded. As much as 1,156 cubic yards has been placed in the forms in 24 hours.

the flared foot of which rests on a concrete wall 10 feet thick and about 10 feet high. On its downstream side, and beginning at a line about 2½ feet below the top, this wall will be cut into for a distance of 5 feet. The opening thus made will be filled with new concrete, which will be placed integrally with the toe of the dam and with the "bucket" extending to the base of Bed "A." From the trench dug for the pouring of the key, the clay will be excavated from Bed "A" as far upstream as this can readily be done and replaced with concrete. These operations will be carried out in stages, with the individual working sections not more than 25 feet long.

Nine Taintor gates, each 51 feet wide, will be erected on top of the hollow section. These will rest on transverse concrete piers, each 9 feet thick and extending into the river bed to the bottom of Bed "A." The piers will rise between existing pairs of

CLARENCE McDONOUGH

General Manager of the Lower Colorado River Authority which is carrying out a program somewhat similar to that of the TVA. Mr. McDonough has had extensive construction experience in the United States and abroad. Prior to assuming his present position he was director of engineering for the PWA in Washington.

in upstream from this area; and after that part of the upstream cut-off wall had been placed and the scheduled grouting done, a cofferdam was constructed downstream, permitting unwatering of the area in question and pouring of the apron, which will extend approximately 35 feet farther downstream than that of the gravity section. It will then be possible also to pour the concrete facing on the eastern gravity-dam section and to build Taintor-gate pier No. 9 at the junction of the gravity and hollow sections.

In view of the necessity of stopping all water from flowing under the dam through Bed "A," the aim is to inject a continuous curtain of grout just upstream of the dam. To accomplish this, a line of holes is being drilled on 5-foot centers to the top of Bed "A" the entire length of the structure. After a thorough washing out of the clay seam with water jets, these holes are grouted. Another row of holes, spaced 10 feet apart, is afterward put down to the same bed, and the washing and grouting operations repeated. On the eastern side of the river, where trouble with seepage was experienced previously, the original holes will be redrilled and again grouted. On the western side this will also be done if there is any evidence of leakage. The holes on 10-foot centers will then be extended to a depth 60 feet below the top of rock. Any clay seams or pockets will be washed out and grouted under pressures up to 100 pounds per square inch. After the cut-off wall at the upstream face is in place, two more rows of holes on 5-foot centers will be put down the entire length of the dam and grouted. The grout holes are being drilled with Ingersoll-Rand Type G-33 and H-3 Calyx core drills.

In the downstream area, the concrete for the apron is poured in blocks 25 feet square. Around each block area, a row of holes is put down to Bed "A" and grouted. Inside the hollow dam, a line of holes on 10-foot centers will be drilled alongside every buttress and every new Taintor gate pier and grouted. Additional grouting will be done if it is found to be advisable during the progress of the work.

The plans call for the construction of a power house just downstream from the dam and at its eastern end. Excavating for the western part of this structure will proceed as soon as it is certain that grouting upstream of the dam in that area has made the subsurface impervious. The power house will contain two 7,500-kva., 200-rpm., 90 per cent power-factor generators. Each will be driven by a 10,000-hp. turbine.

One interesting phase of the operations is the necessity of safeguarding the existing dam against possible damage. This makes it impracticable to use explosives except in very small quantities, and then only at some distance from the structure. As a result, the cutting through of the diversion slot, the stripping of the granite facing of the gravity dam, and all other rock-removal jobs in or immediately adjacent to the dam are being done with paving breakers, chisels, picks, and similar tools. Rock is broken by the plug-and-feather method. In excavating the trench for the "bucket" at the toe of the dam, the upstream boundary cut is made in the granite masonry by drilling and broaching with four skid-mounted wagon drills. In the underlying limestone at that location, and in digging the keyway at the downstream edge of the apron, holes are put down close together and shot with one quarter of a stick of dynamite in each one. All drilling is done with Jackbits. Side-hole bits are used in the river bed because the clay seams encountered there tend to clog center-hole bits. Jackbits are reground three times, two J2 Jackbit grinders being used for that purpose. Shanks and threads are forged on the drill rods in a No. 54 I-R sharpener.

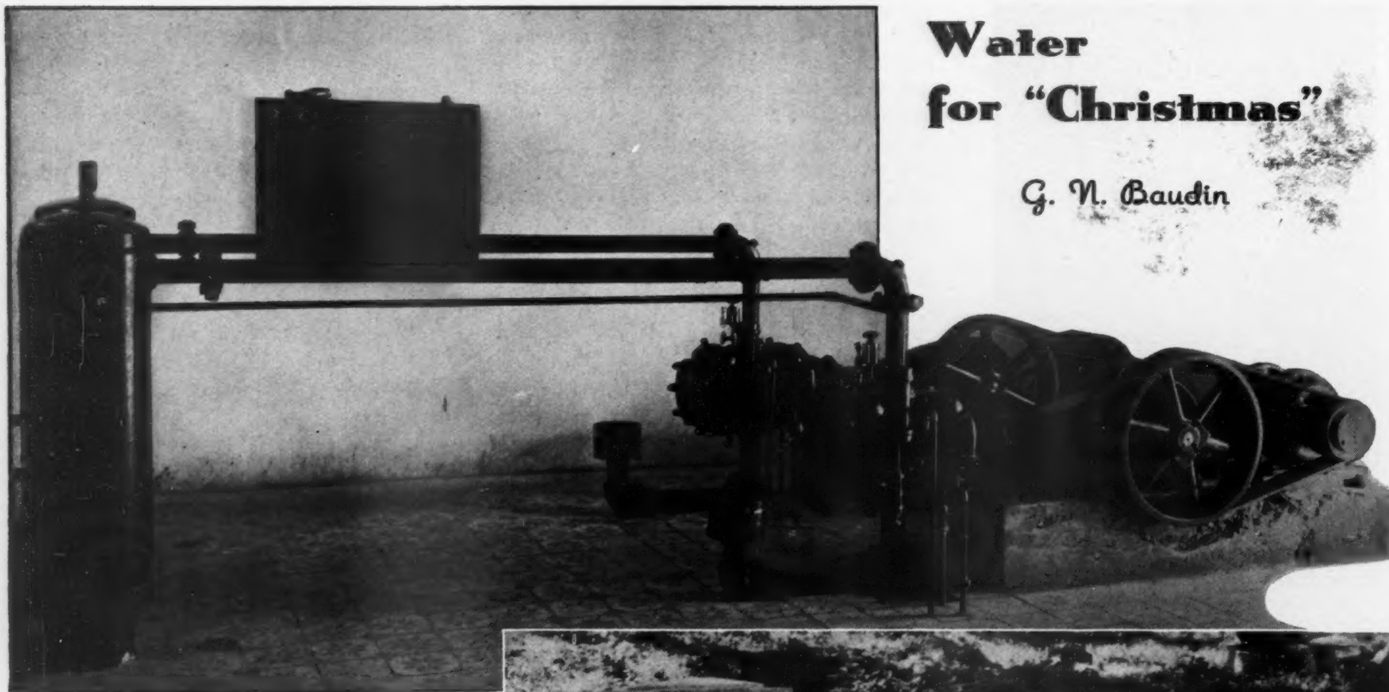
The undertaking calls for the pouring of approximately 100,000 cubic yards of concrete. To supply this, a complete mixing plant has been established adjacent to the eastern end of the dam. Storage is provided for 9,000 cubic yards of aggregates ranging in size from 3/16 inch to 3 inches. A conveyor belt runs in a tunnel beneath the piles to bins at the mixing plant located at a higher elevation and above the old headgate masonry close to the end of the dam. Cement is stored in an underground steel silo and delivered to the mixing plant by a Fuller-Kinyon air-operated conveyor system. Two 2-cubic-yard Ransome concrete mixers, having a capacity of 160 cubic yards an hour, are served by Blaw-Knox batching equipment. Each batch of concrete is mixed for two minutes. A 70-foot chute extends from the mixers to a loading platform for trucks on the downstream side of the dam. There the concrete is dumped into 2-cubic-yard buckets which are hauled to points of use and lifted from the trucks by a crane for delivery to pouring locations. All concrete is compacted with Ingersoll-Rand IV air-operated vibrators. A railroad traveling along the top of the dam and made up of bottom-dump cars of 4 cubic yards capacity drawn by a Plymouth gasoline-powered locomotive will deliver concrete for pouring the eastern end of the structure and also the power house. Up to Elevation 486, which is within a few feet of the crest, the concrete will be placed in the forms through tremies.

Clarence McDonough is general manager of the Lower Colorado River Authority and is in charge of carrying out its program covering the building of dams for flood control and the generation of power. R. B. Alsop is superintendent of construction on the Austin Dam as well as on the other construction work being done by the Authority. The engineering phases and the design of the Austin Dam are in the hands of the Authority's own forces. G. L. Freeman of the New York engineering firm of Moran, Proctor & Freeman is consulting engineer. He is devoting his personal attention to the Austin Dam and makes monthly visits to the site. George F. Harley is engineering representative of the Public Works Administration on the project. Nearly 600 men are employed in three shifts six days a week on the Austin Dam.

The Lower Colorado River Authority is directed by a board of nine members of which Fritz Engelhard is chairman. The others are T. H. Davis, C. R. Pennington, Carl White, William B. Arnold, Charles Matula, S. Raymond Brooks, Roy Fry, and J. F. Hutchins.

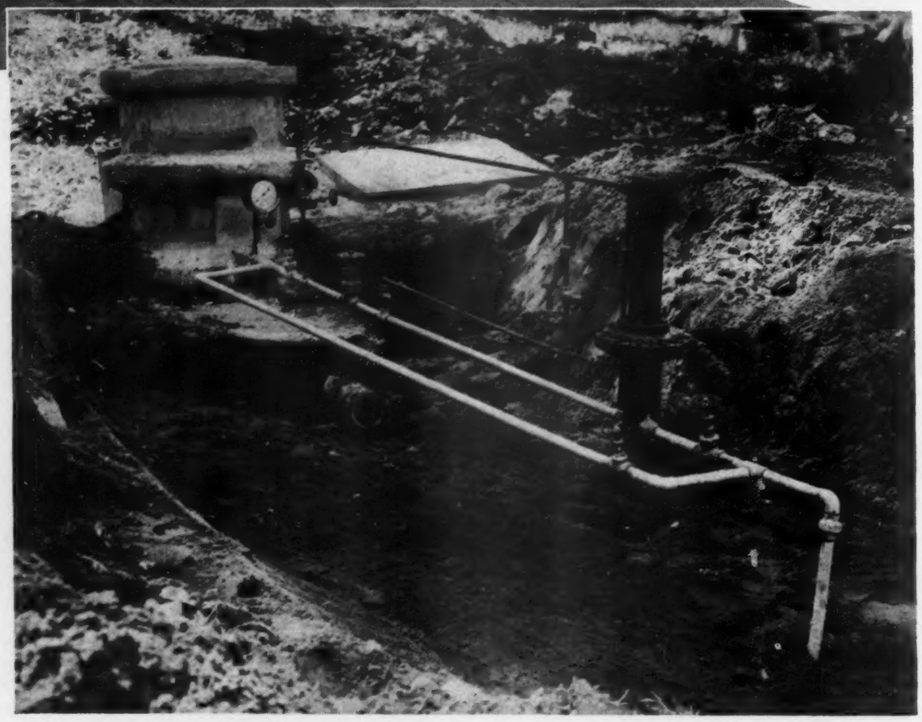
ROBERT B. ALSOP

Superintendent of construction for the Lower Colorado River Authority since June 1936. He is personally directing the rebuilding of the Austin Dam. As a timekeeper for the Foundation Company in Chicago, in 1909, Mr. Alsop began an extremely active construction career during which he has had charge of operations of various kinds in many sections of the country.



Water for "Christmas"

G. N. Baudin



COMPRESSORS AND A WELL

The picture of the well, which is one of ten, shows the Thomas automatic control which conserves air and maintains the output of each well at a substantially constant rate. The two single-stage compressors deliver sufficient air to pump the ten wells, under normal conditions, at 20 to 40 per cent greater capacity than is required. There is, accordingly, a reserve supply of air available for use during drought periods when the ground-water level is abnormally low. Many air-lift plants of the type covered in this article have been operating dependably in Brazil for twenty years or more with the original equipment.

ON December 25, 1599, Capitao Jeronymo de Albuquerque founded the Brazilian city which is now the capital of the State of Rio Grande do Norte. In commemoration of that date he gave it the name *Natal*, meaning Christmas Day. Natal is now a thriving community of some 45,000 inhabitants that receives frequent mention in press dispatches, particularly in connection with aviation matters. Owing to its location at the easternmost tip of Brazil and only 2,000 miles from the African coast, it is the natural terminus for transatlantic air mail. Almost every day a big plane of the Lufthansa or the Air France Line arrives from or departs for Berlin or Paris via Bathurst or Dakar.

In common with many cities in the arid northeast of Brazil, Natal has difficulties in obtaining an adequate supply of water. A large proportion of it now comes from wells; and when the growth in population recently necessitated an increase in the supply, it was decided to drill additional wells.

As an existing air-lift plant equipped with Ingersoll-Rand compressors had given reliable service for nearly twenty years, the air-lift system was naturally given consideration in planning the new installation. Ten 6-inch wells were drilled to depths of from 70 to 300 feet, and these were tested for capacity and drop with a 105-cfm. I-R portable air compressor and a "VC" footpiece belonging to the department of the federal government in charge of drought relief. On the basis of the test data so obtained, and after weighing the relative merits and over-all operating costs of the air lift and of deep-well centrifugal pumps, it was decided to equip the wells for air-lift pumping and to use the "VA" or outside air-line type of footpiece for maximum efficiency.

As the operating pressures required varied all the way from 18 pounds per square inch for the shallowest wells to approximately 50 pounds for the deepest ones, the wells were provided with the Thomas type of automatic volume control. The principal advantage of this type of control is that once the adjustable orifice valve has been set for a given volume of air at a given pressure, corresponding to the operating submergence of the well, the volume is thereafter automatically maintained at a constant rate by the device. This prevents poor wells, whose operating pressures have been reduced by a drop in the water level, from "robbing" air from good wells. Consequently, the output of each well is maintained at a substantially constant rate in accordance with its calculated capacity for maximum efficiency.

For a specified output of 1,000 cubic meters (35,315 cubic feet) of water a day from the ten wells, two 7x5-inch Ingersoll-Rand Class ER-1 air compressors were in-

SCENES IN NATAL

Natal is a thriving city with a population of 45,000. Its location at the easternmost tip of Brazil has made it the logical South American base for airplanes flying to and from Europe by way of Africa, which is only 2,000 miles distant. At the right is shown a tri-motored Junkers plane of the Condor Line Rio de Janeiro-Belém (Pará) on the beach at Natal.

stalled. Each is driven by Texropes from a 15-hp. General Electric motor. The compressor sizes were calculated with a certain margin of capacity to take care of the water-level drop in dry seasons. Either unit is capable of pumping approximately 75 per cent of the required capacity under normal conditions, while the two machines will actually provide anywhere from 20 to 40 per cent more water than the minimum requirement, amounting to 1,000 cubic meters daily.

The value of the automatic control equipment was shown clearly during the first few days of operation. Before it was adjusted, and while the air supply was being regulated by hand-operated by-pass valves alone, it was possible to pump only four wells. But as soon as the automatic control was put in service, the same amount of air sufficed to pump all ten wells at capacities in excess of their ratings.

The air-lift system is widely recognized throughout Brazil as the most satisfactory one for pumping drilled wells under the existing conditions of variable water level and appreciable quantities of sand which causes rapid wear of casings and impellers of centrifugal pumps. As the air lift has no moving parts subject to wear inside of the well, and as a modern heavy-duty compressor seldom needs adjustment or repair, a single well will be a highly reliable source of water, and heavy charges for standby pumping equipment can be eliminated. Many wells of this type in Brazil have been pumped well-nigh continuously for twenty years or more with the original installation. In addition, the over-all efficiency of a properly designed air lift compares favorably with that of other types of deep-well pumping equipment, and efficiency is maintained indefinitely.

In carrying out the new water-works program for the Natal Sanitary Commission, the Escritorio Technico R. Saturnino de Britto, of Rio de Janeiro, served as consulting engineers. This well-known firm has been responsible for the designing of many of the new water works throughout the north of Brazil.

Speed of Action Feature of New Carillon

THERE is now on exhibition at the Golden Gate International Exposition a carillon that was built in England for Grace Cathedral in San Francisco, Calif. It numbers 44 bells, and embodies several unusual features that enable it to be played with nearly the same speed as a modern organ. The instrument is operated either mechanically through the medium of perforated paper rolls or by a pianist or organist who fingers a keyboard the same as that of a piano.

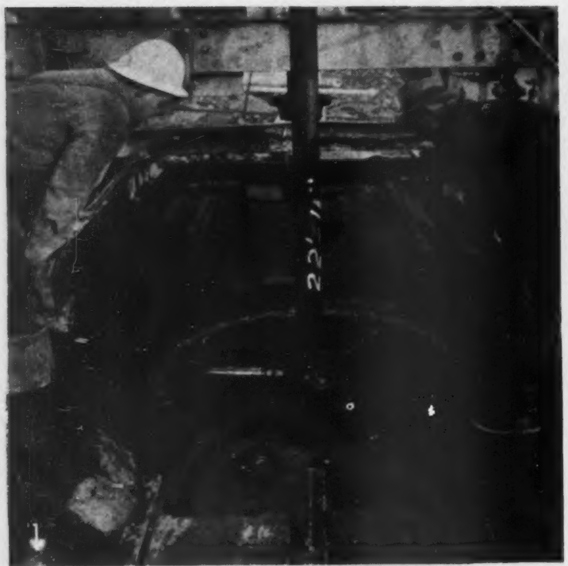
The exceptional rapidity with which the bells are struck is attributable in large part to the carillon's electro-pneumatic system which differs in a number of particulars from that generally used to actuate the clappers. Ordinarily, the pneumatic pistons which are coupled to the clappers are placed underneath the belfry floor, thus necessitating long connecting draw wires. In the case of the Grace Cathedral instrument, these wires have been materially shortened by mounting the piston banks on brackets attached to the framework in which the bells are suspended. One drawback of this arrangement is that the piston assemblies are exposed to the destructive action of the elements. However, this has been offset by making them weatherproof and by giving them the further protection of removable covers.

In addition to this improvement, the usual reserve air cylinder is dispensed with. Instead, there is housed in each group of pistons, in a space especially provided for that purpose, an air storage chamber which takes its supply direct from a compressor through a connecting pipe line. In this way an adequate amount of air is made available at the point where it can do its most effective work. Air at 40 pounds pressure per square inch is used, and is furnished by a single-stage machine driven by an electric motor.

Another departure that contributes measurably to the responsiveness of the bells is the relay system by means of which the piston-control circuits are completed when a note is struck either on the keyboard or by the mechanical player. These relays are of the same type as those used in automatic telephony. To assure proper functioning, a master contact is provided that prevents tripping of the piston-release magnets until sufficient pressure has been built up for the operation of the clappers.

Owing to the construction of the tower in which the carillon is to be placed, the bells could not be arranged in the customary fashion. Instead of being grouped together, the large and the medium-sized ones are hung separately, with the small treble bells in between. The 5½-ton bourdon bell is suspended below in its own framework and is set in motion by means of a 2-hp. motor much the same as it would be by a bell ringer. Once the prescribed arc of swing has been attained, the bell continues to ring without variation until it is stopped at the remote-control station. The instrument's 44 bells have a combined weight of 18 tons and are tuned on modern harmonic principles. They are said to have a remarkably pure tone.

48-inch Pilot Shaft Sunk with Calyx Core Drill



1—One of the spiders that keep the drill rods centered.

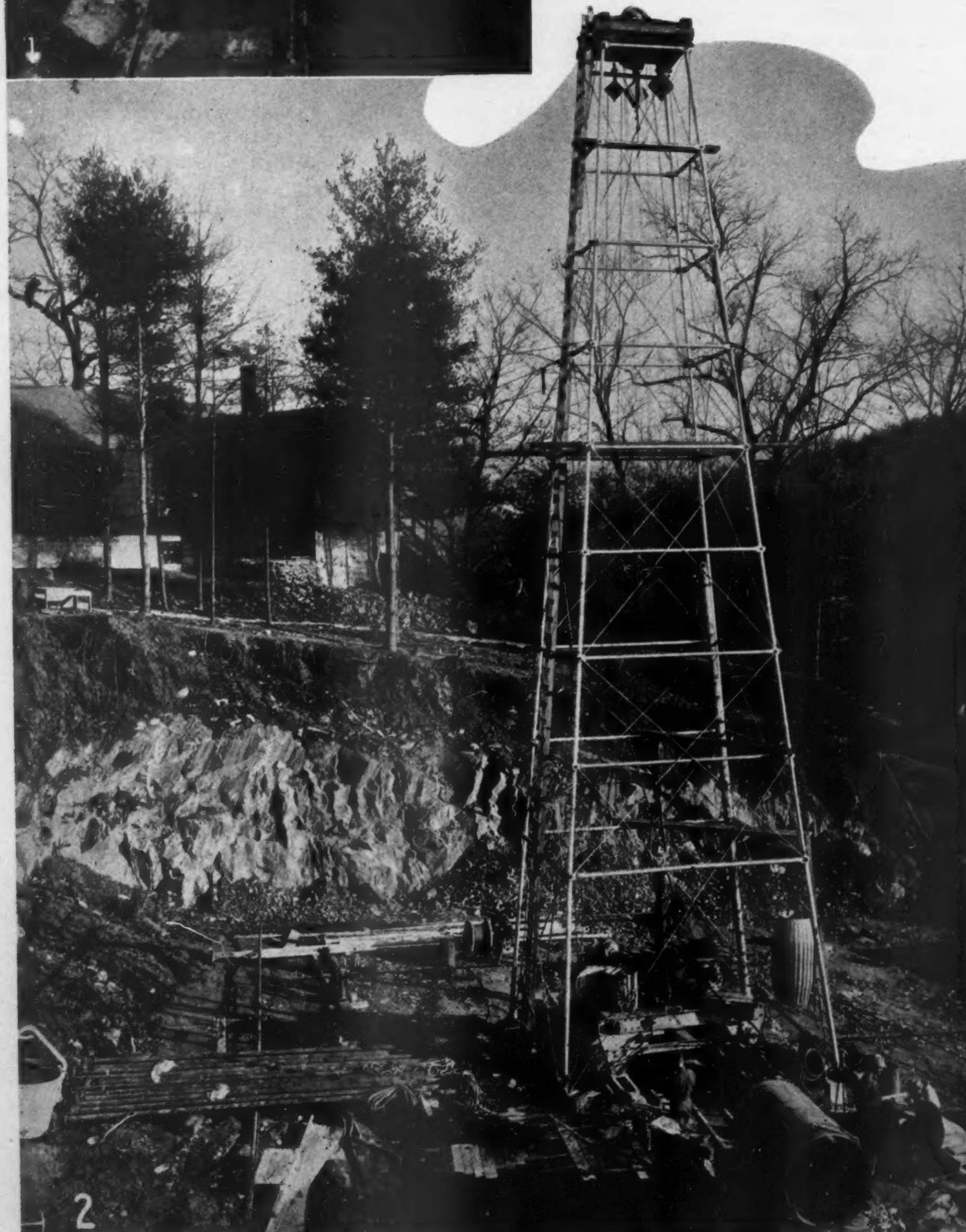
2—The 66-foot steel derrick. On the ground at the left are sections of drill rod. In the foreground is the core lifter. The vessel at the right-hand derrick leg is a water bailer.

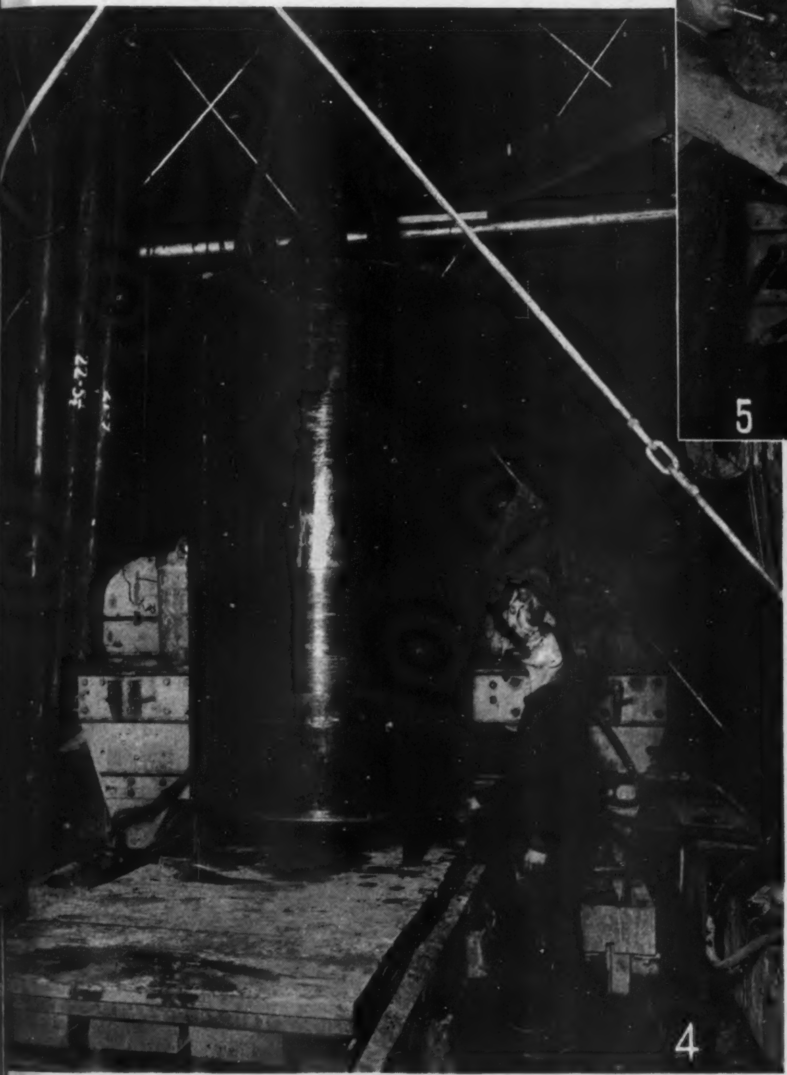
3—Lowering the Calyx core barrel into the hole to resume drilling, following the removal of a core. Drill rods that are to be connected to it are shown at the left.

4—The core lifter which is lowered down over the core and is then made to grip it so that it can be removed.

5—Before the core lifter is put down the hole, a small piece of dynamite is attached at the bottom of it. This is later fired from the surface to break the core loose from the mother rock.

6—A section of the 48-inch core showing the smooth, regular cut obtained.





THE Seaboard Construction Company, operating on Section 13 of the Delaware River Aqueduct at Katonah, N. Y., recently completed the drilling of a 300-foot circular shaft, 4 feet in diameter, through rock with a Calyx shot drill. When enlarged to 24x30 feet, this shaft will house control valves and other gatehouse equipment required in conjunction with the underground aqueduct which will convey water to New York City from the upper regions of the Delaware Valley..

This is the second shot-drill hole that has recently been sunk for enlargement later by regular drilling and blasting operations, the first one having been drilled in Arizona. This Calyx-bored hole intersects the tunnel line, and thus all muck produced by enlarging the Calyx hole will be dropped into the tunnel and carried away with the spoil from the tunnel headings.

The Seaboard Construction Company's contract called for the sinking of but one shaft. After all drilling had been completed and the finished tunnel lining placed, it was contemplated installing the gatehouse equipment in that shaft. The contractor, however, decided to sink an extra shaft to the tunnel line some 200 feet "downstream" from the gatehouse. This shaft, put down by conventional methods, is being employed for removing tunnel muck. By virtue of the time saving made possible by the second shaft, that is to be created by enlarging the Calyx bore, the contractor will be able to have the gatehouse equipment installed upon the completion of the tunnel itself. It is estimated that the job will be finished some eight months ahead of schedule.

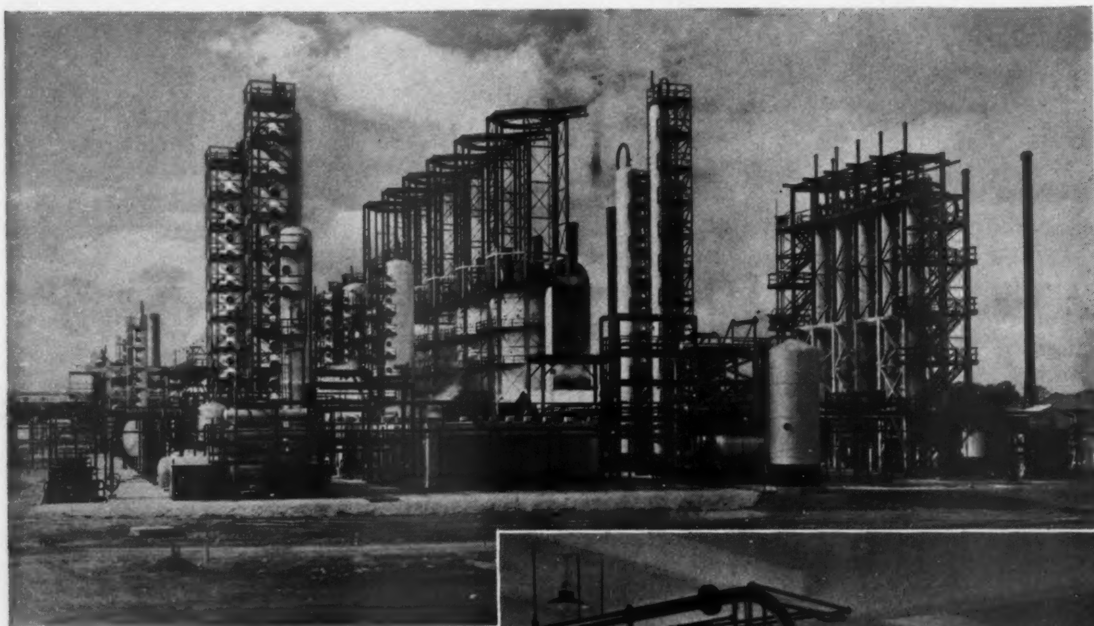
The Calyx drill rig that was used for this work is provided with a 50-hp. electric motor which drives the drill rod and cutter through reduction gearing at 50 rpm. During hoisting, the entire driving mechanism is moved back and away from the hole on rails. Separate hoist lines are utilized for handling drill tools and removing cores and for operating the seepage-water bailer and the man line. The derrick tower is a 4-legged steel structure 66 feet high. Three- and four-part lines serve to do the heavy hoisting, while a single line is used for light hoisting. Because of the size of this installation and the amount of work that had to be done, a separate engine-driven hoist was set up a short distance from the drill rig and housed in.

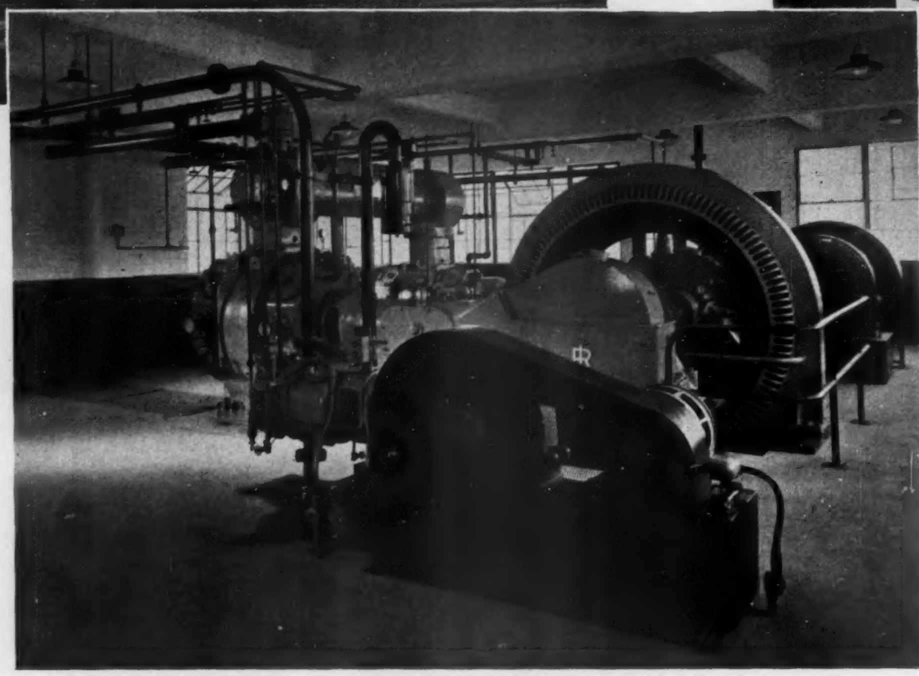
Most of the core taken from this hole was removed with the aid of the split-sleeve type of core lifter shown in the illustrations. When lowered into the hole it grips the base of the core very close to the bottom of the cut. This gripping action takes place as tension is applied to the hoisting line from the surface.

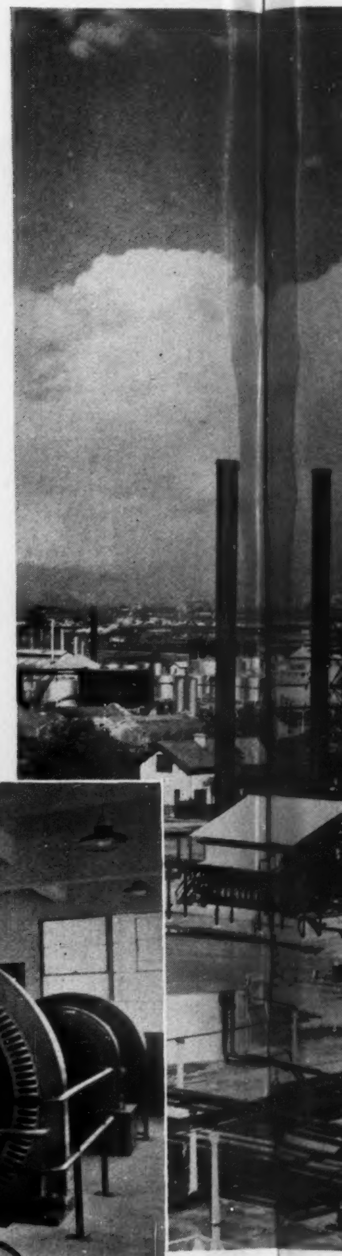
The pilot bore will be enlarged to full size by ring drilling and blasting. These operations will be conducted progressively from the bottom to the top, and a hopper with a loading chute will be constructed at the bottom to trap the muck that falls. The initial enlargement will have to be done with a Jackhamer and short steels because of the limited working space available. Subsequent operations can then be carried out with heavier drills and longer steels.

Richfield's New Oil Refinery

Allen S. Park







TIERS OF TOWERS

A general view of the refinery that gives an indication of the intricacy of the assembly. By scheduling the delivery of each unit in order, and by setting up suitable rigging equipment, even the largest of the towers shown was in place on its foundation within an hour after the car bearing it was spotted on one of the spur railroad tracks serving the construction area. An idea of the size of some of these towers can be obtained from the picture on the front cover.

COMPRESSOR ROOM

These three Ingersoll-Rand units each supply compressed air for a separate purpose. In the foreground is a 15-hp., single-stage machine whose output is used for operating instruments and controls. Back of it is a 600-hp., synchronous-motor-driven unit that furnishes air for general plant requirements. In the background, with only the motor visible, is a 100-hp., single-stage compressor that supplies the air employed in regenerating the catalyst in the polymerization unit.

THE Richfield Oil Corporation has recently put in service at Watson, Calif., a $5,000,000 refinery that is notable for its modernness and efficiency and also for the well-ordered manner in which it was designed and constructed. Constituting one of the largest refinery plants ever built under a single contract, it was erected and placed in successful operation with scarcely a hitch. The success achieved is attributable to the care and thoroughness of the advance engineering, close coördination of design and manufacture, and forethought on the part of the builders. The refinery location is 2 miles from Los Angeles Harbor and only a short distance from the Signal Hill oil field.

The main plant consists of two identical combined topping and cracking units which produce gasoline directly from crude oil and also crack the reduced crude residue from the first process to obtain additional gasoline, as well as other petroleum derivatives. Each unit has a charging capacity of 25,000 barrels a day. The flexibility is such that the charging stock may vary all the way from 20,000 barrels of crude oil and 5,000 barrels of reduced crude to 10,000 barrels of crude oil and 15,000 barrels of reduced crude. Auxiliary units take care of debutanization, stabilization, removal of hydrogen-sulphide, dehydration, depropanization, caustic washing, and catalytic polymerization.

When the Richfield Oil Corporation was reorganized in March, 1937, by consolidating the assets and properties of the Richfield Oil Company of California, Pan American Petroleum Company, and Rio Grande Oil Company, it acquired a refinery from each of the three concerns. Save for the Rio Grande plant at Vinvale, Calif., however, these establishments were out of date and in run-down condition. As the Vinvale refinery was too small to supply all the requirements of the new company, and as it

GENERAL PLANT VIEW

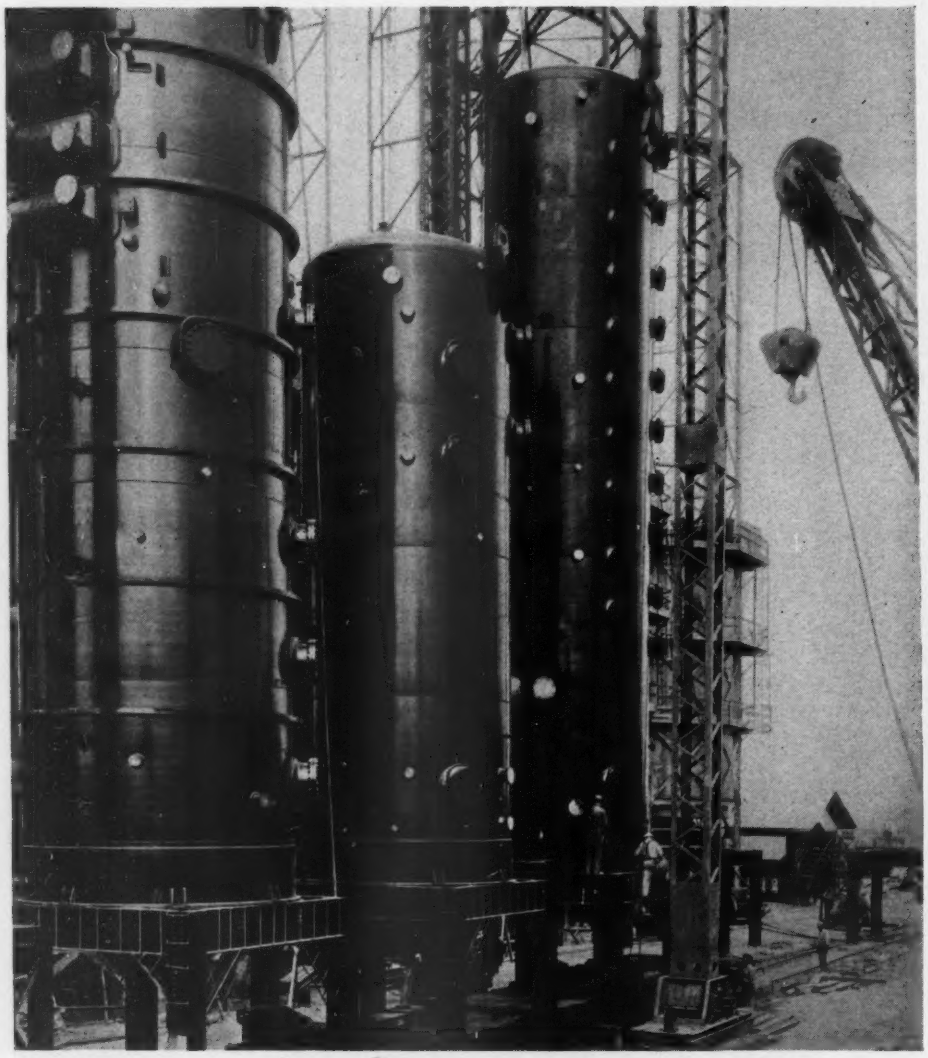
Erected under a single contract of $5,000,000, this refinery brings the manufacturing facilities of the Richfield Oil Corporation up to date and makes possible the production of high-grade petroleum derivatives at low cost. It is located strategically with respect to the company's principal markets. The plant began operating at capacity as soon as it was completed, and was shut down after 30 days for the sole purpose of inspecting the equipment. During this trial period there was no enforced shut-down. Signal Hill oil field is visible in the background.

was uneconomic to operate all three plants, the first concern of the management was to develop adequate and modern refinery facilities at a location well centralized with respect to the company's markets.

In the reorganization proceedings, an agreement had been entered into with the Sinclair Refining Company providing that the latter could be called upon to furnish engineering services. Accordingly, Richfield requested the Sinclair development department to survey the existing refinery facilities and to recommend a plan for revamping them. Careful study indicated that rehabilitation of existing equipment would be unsatisfactory because operating costs would be too high and because the products would not be sufficiently high grade to satisfy the prevailing demand. After considering both the economies and the technical aspects of the problem, the Richfield management decided to concentrate its manufacturing operations in a new refinery at Watson and to keep the plant at Vinvale in readiness against the possible need of additional production.

Contracts for the major part of the plant were let on July 14, 1937, to C. F. Braun & Company of Alhambra, Calif. These included the building and installation of the distillation and cracking units, debutanizer, hydrogen-sulphide removal plant, polymerization unit, and caustic-wash unit. Other Braun contracts covered the reconditioning of an existing battery of crude-oil stills and the rehabilitation of the electrical and water systems.

Preceding actual construction work, the refinery had of course to be built on paper, a task that was quickly and capably accomplished through close coöperation between the engineering staffs of Sinclair, representing Richfield, and of the contractor. By August the site had been cleared; and the first concrete foundations were poured in September. The problem then was to keep equipment moving in as it was needed. On a job of this size, this would have been difficult under normal circumstances; and it was still further complicated by heavy rains in the spring of 1938. Con-



CONSTRUCTION SCENE

Erecting a 13-foot-diameter fractionating column in one of the combination topping and cracking units. The picture shows some of the special equipment provided to handle that work expeditiously. An enviable safety record was made, there being no fatality, no serious-injury case, and no accident involving claims for property damage, public liability, or rigging risks.

trary to usual practice, the plant was largely shop-fabricated, thereby simplifying and expediting work in the field. All the major refining equipment and some 10,000 complete units of piping and accessories were manufactured and tested at the Braun factory and shipped to the plant site ready for assembly.

Some transportation problems were occasioned by the size of individual pieces of equipment. Each of the two topping and cracking units requires seven evaporating and fractionating towers, the largest of which measure 13x60 feet and weigh 250,000 pounds. When these towers were loaded on flat cars they would not clear cars on adjacent tracks, and it was consequently necessary to enforce 1-way traffic while they were en route from the factory to the refinery site.

The delivery of equipment and materials was coördinated with the construction schedule to such a degree that most of the units could be moved directly into place from cars or trucks without rehandling. Two spur tracks extended from one end of the plant area to the other, and were located so that major pieces of equipment could be conveniently unloaded from cars and put in their allotted positions. A gallows frame, three heavy-duty hoists, three traveling cranes, two hoist trucks, a stiff-leg derrick, and seven air-operated "Little Tugger" hoists were included in the rigging equipment. By means of these facilities, the erection on their support structures of large bubble columns, weighing from 90 to 140 tons each, was accomplished within one hour after the cars bearing them were spotted. These columns were manufactured and shipped in a planned sequence which permitted moving the rigging apparatus in one direction and in short steps, with no back-tracking.

Approximately 6,000 separate units of piping were fabricated and tested in the Braun plant. Piping that was to be subjected to temperatures of 600°F. and higher was made from a very low-carbon alloy steel in which the element columbium was used to lessen the likelihood of air-hardening defects. These lines were provided with vanstoned flanged joints so as to avoid, so far as possible, welding the alloy steel. Approximately 40 miles of lead-covered cable and rubber-covered wiring, and more than 16 miles of thermocouple wiring, all carried in galvanized conduits, are included in the electrical system. All power-distribution lines, both between and within the several units, are placed underground in conduits which are encased in concrete. In addition to the foregoing, many miles of instrument piping and conduits are routed throughout the units in supporting racks. The six de Florez vertical cracking furnaces contain some 7 miles of alloy-steel tubing. The tubes were rolled into headers, there being 1,900 of these joints. No leaky joints were found either during the hydrostatic tests or when the units were placed in operation under plant temperatures.

Great care was taken in aligning the pumps, motors, and turbines, with the result that when the plant was started or "put on stream," to use refinery terminology, operation was not once interrupted. Each of the 50 pumping units in the main plant and the 40 in the auxiliary units were aligned, shimmed, and grouted, and the alignment was rechecked after the pumps had been run in.

The refinery water system, which was built concurrently with the plant, is of such a size that it would meet the demands of a city with a population of 300,000. It cools and circulates 24,000 gpm. This water is obtained from five wells varying in depth from 650 to 800 feet. There are four cooling towers over which water that has become heated in process work is passed for cooling and re-use. The wells are therefore required to furnish only sufficient water for make-up purposes. The water mains are 36 inches in diameter.

Despite the magnitude of this job, it was completed with an outstanding safety record. There is an old superstition that one life is lost for each $1,000,000 worth of construction done. In this instance no lives were lost and no one was seriously injured. Moreover, there were no accidents involving claims for property damage, public liability, or rigging risks.

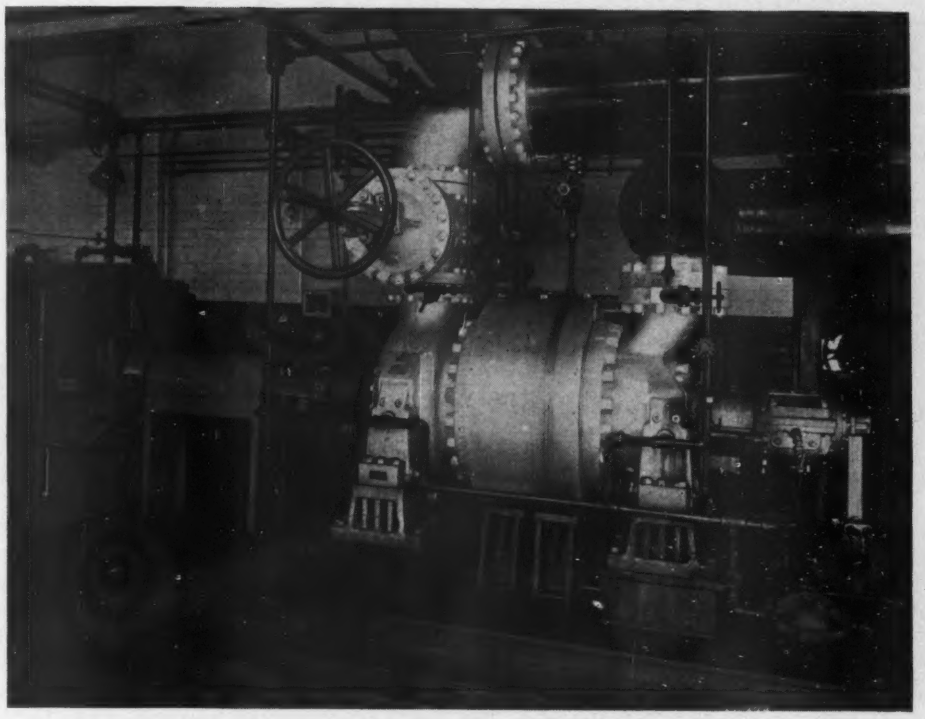
Although the flood conditions that prevailed in the spring of 1938 seriously impeded activities, the plant was ready for service on the scheduled date. All pressure vessels and piping were subjected to hydrostatic tests, and these were followed by a period of flushing out and circulation of cold gas oil. The pumps were run in and checked, instruments and controls were tried out, and the flow directions were determined. These inspections and preliminaries were conducted with great thoroughness by the Sinclair and Richfield engineering and operating staffs.

During the latter stages of the construction period the Richfield men who were to run the combination units went over the plant each week so as to become familiar

with every engineering detail. Key men were sent to Sinclair refineries to obtain experience with similar equipment. As a result of the care taken in building and testing the equipment and in training the personnel, the combination units, having a combined charging capacity of 50,000 barrels daily, attained full operating capacity within one week after they were put in service.

Briefly summarized, the flow through the plant is as follows: After being preheated, crude oil is charged into a flash column where it is separated into three products. Straight-run gasoline comes off at the top, kerosene is obtained as a side stream, and there remains a residuum that undergoes further refining. This residuum, together with reduced-crude from extraneous sources, is fed into a gas-oil evaporator column which also receives the oil and vapors discharged from the cracking coils. The overhead vapors from this evaporator consist largely of cracked distillate, which is passed directly to a fractionating column. The residue from the evaporator is distilled under high vacuum. The vapors that come off overhead are in the gas-oil range. These are condensed and then fed, along with gas-oil from extraneous sources, to a fractionating column, and from this they are charged into the cracking furnaces. The discharge from the furnaces enters the gas-oil evaporator, from which the overhead discharge of pressure-distillate and some gas oil flows to the fractionator. The latter is designed to make three products or "cuts": an overhead pressure-distillate, a side stream of gas-oil, and a residuum that is returned to the cracking furnaces. The pressure-distillate is fractionated in a debutanizer and stabilizer to produce three streams: butane-free gasoline, stabilized gasoline, and hydrocarbon-vapor feed for charging the polymerization unit. The vapors going to the polymerizer are first stripped of their hydrogen sulphide in a tripotassium-phosphate unit, and are then dehydrated. The polymerizer, consisting of five towers in series, is a Universal Oil Products Company nonselective catalytic unit. The polymer gasoline made in it is stabilized, blended with cracked casinghead gasoline, and the product passed through a caustic-wash unit to remove objectionable compounds.

The movement of the raw materials and of the intermediate and final products in a refinery of this size requires numerous pumps, and each must be suitable for handling its particular type of liquid under the pressure and temperature conditions that prevail. There are 47 Ingersoll-Rand centrifugal pumps in the main section of this plant. Of chief interest are the units that feed the hot charge into the cracking furnaces. There are two of these—one for each furnace, and they are so vital to the functioning of the refinery that a spare, completely assembled, is kept in the warehouse. Each pump is designed to handle 1,400 gpm. of oil at 660°F. against a discharge pressure of 800 pounds and with a suction pressure of 60 pounds and is driven by a General-Electric 1,000-hp. motor with a double-extended shaft for the application of an auxiliary steam turbine. Because of the fire and explosion hazards at the points where such equipment is placed, hot-oil pumps have previously always been driven by steam turbines. In this instance it was possible to take advantage of the economies of electric drive by designing motors that operate continuously in an atmosphere of carbon dioxide. They are the first carbon-dioxide-filled induction motors ever built.



HOT-OIL CHARGING PUMP

Each of the two cracking units is served by one of these Ingersoll-Rand Type AHT 6-stage centrifugal pumps of advanced design. Each can handle 1,400 gpm. of charging stock against a pressure of 800 pounds and at a temperature of approximately 660°F., with 60 pounds pressure on the suction. At the left is shown the General Electric 1,000-hp. driving motor which runs in an atmosphere of carbon dioxide to eliminate the fire and explosion hazard. External water coolers keep the gas at a temperature of less than 104°F. These pumps have the largest horse-power rating of any so far placed in operation in a California refinery. They are constructed of special materials to withstand the severe service conditions and are built with the utmost care and precision.

The carbon dioxide is fed into each motor from a cylinder through a reducing valve, and a slight pressure is maintained in the interior. As a result of close fits, tight connections, and bearing seals, only one 50-pound cylinder of carbon dioxide is required every two weeks to replenish the supply. There is a surface air cooler on each side of the motor, and by circulating cooling water through these the temperature of the carbon dioxide is kept below 104°F.

The compressed air needed is furnished by three Ingersoll-Rand compressors. A 600-hp., direct-connected, synchronous-motor-driven Class PRE-2 unit of approximately 3,000 cfm. piston displacement serves general plant requirements. A 100-hp., electric-driven Class ESE-1 machine of 931 cfm. piston displacement supplies air for use in regenerating the catalyst in the polymerization unit, while a 15-hp., belt-driven Class ES-1 unit with a piston displacement of 161 cfm. provides compressed air for operating controls and instruments.

Each of the five catalytic polymerization towers is periodically taken out of service for reactivation of the catalyst. This is accomplished by first passing through it flue gas at 30 pounds pressure, together with carefully controlled small blasts of air for the removal of carbonaceous matter by burning. The flue gas is a product of perfect combustion and, prior to its use, is dehydrated by cooling and then heated to 700°F. After the catalyst has been cleaned, superheated steam is passed through it for the purpose of restoring the proper moisture content.

The plant is as nearly automatic as it can be made, and it is doubtful if any number of operators could coördinate their efforts so as to provide the exacting control that is obtained mechanically. There are more than 100 diaphragm-type motor valves that are actuated by compressed air. They range in size from ½ inch to 10 inches. The control board on which are mounted the instruments that relate to plant operations is 83 feet long and 8 feet high.

MOVIES FROM BALLOONS

IN CONJUNCTION with studies aimed at simplifying traffic on state highways, the Safety Department of the Division of Highways in California has recently experimented with aerial motion pictures. The results were so successful that the procedure will likely be made standard practice.

The traffic engineers are concerned chiefly with collecting and analyzing what they term traffic patterns, which they define as the recurrence of certain driving habits of motorists. Obviously, if they can determine the form that traffic streams most often take on a certain stretch of roadway where accidents occur, they will be in a better position to learn the causes of those accidents and to set up controls that will decrease the hazards.

It has been learned that the behavior of motorists is influenced to a greater or lesser degree by various extraneous conditions such as the highway structure, roadside development, and the actions of other drivers. The study of traffic streams from the ground is not satisfactory, because the human eye is distracted and cannot follow the course of one car to the exclusion of all others. Furthermore, the eye cannot make a permanent record for investigation later on. The camera has none of these disadvantages.

Some time ago the City of Milwaukee attached a still camera to a captive balloon and took pictures to aid in planning street intersections. The scheme worked well; but photographs could be made at the rate of only one every fifteen minutes. To overcome this objection, the California engineers decided to try making movies by a similar method. The Goodyear Tire & Rubber Company and the Bell & Howell Company, camera manufacturers, coöperated in designing and furnishing the necessary equipment.

A 16-mm. motion-picture camera was mounted on an aluminum frame to which was attached a solenoid and plunger connected to the shutter release and actuated by a power supply on the ground. The entire assembly was suspended from an 11-foot spherical balloon so that it would swing free, with the camera lens normal to the ground. The balloon was filled with helium gas and sent aloft. Two bronze guy wires and a steel cable held the balloon in position over the road, and one of the former served as a line to transmit the current for the release of the shutter. The operators took a position where they would not be visible to motorists. Whenever traffic developed, the camera was started by remote control, and it was stopped as soon as the vehicles had passed the point of study. By slowing the camera to half normal speed, or to eight frames a second, 100 feet of film was made to serve for more than eight minutes.

The traffic experts believe that movies will enable them to isolate the occasional motorist whose bad driving habits contribute to many accidents. They will also make it possible to pick out features of design or roadside-view obstructions that affect drivers detrimentally. The day may come soon when balloons will be standard working paraphernalia of our state highway departments.

THE "SQUALUS" DISASTER

THE regrettable accident to the United States submarine *Squalus* was tragic enough; but the loss of life would have been still more appalling had it not been for the special diving bell that was then used for the first time. Just as the submarine itself is dependent upon compressed air for its functioning, so is this modern apparatus for salvaging human lives from Davy Jones's locker dependent upon that medium for its operation.

Diving bells of one sort or another have been in use for many centuries. According to Aristotle, Alexander the Great employed one in his siege of Tyre, but we know nothing about its construction. Throughout the ages, inventors have striven to develop workable, submersible chambers in the hope of recovering the vast fortunes in jewels and bullion that have gone down with ill-fated vessels. In recent years, apparatus of this sort has been devised for underwater construction work.

Following the sinking of the submarine *S-4* off Cape Cod in 1927, with the loss of her entire personnel, a board was appointed by the Secretary of the Navy to investigate safety devices for submergible craft. The nation was stirred by the disaster; and the board received more than 8,000 letters of which 5,000 contained suggestions for coping with similar situations in the future. Of all the devices reviewed, only the "lung" was endorsed by the board, although some of the members looked upon the diving bell with favor. Each man aboard the *Squalus* had one of these "lungs"; but they would have been used only as a last resort because the water pressure at the 240-foot depth amounted to 100 pounds per square inch. In their rapid ascent to the surface, the men inevitably would have suffered greatly and, possibly, fatal effects from the compression and subsequent expansion of the nitrogen bubbles in the bloodstream.

The rescue chamber that saved 33 of the 59 men in the *Squalus* is a steel-framed vessel shaped like an inverted pear. It was developed by Commanders Allen R. Mc Cann and A. I. McKee, who hurried from Washington to the scene of the sinking to direct its operation. Buoys released from the *Squalus* marked her location and enabled divers to go down and fasten a cable to the escape hatch of the forward torpedo room. Down this cable the rescue chamber reeled itself, a compressed-air motor operating the winch that pulled it. Arrived at the hatch, compressed air served to force the water out of the lower compartment, and then the pressure of the water held the chamber's rubber-gasketed bottom tight against the submarine, permitting the hatch to be opened. Nine men were admitted into the bell; the hatch was closed; sea water was let into the lower compartment; and the ascent was made. Three more trips followed, saving all aboard who were still alive. Thus out of tragedy are born means to avert tragedy.

This and That

Better Bessemer Blowing

An improvement in the control of the time of blowing molten iron in a Bessemer converter has been announced by the Jones & Laughlin Steel Corporation and promises to have far-reaching effects on steel-making procedure. The new method is called the "Bessemer Flame Control," and depends upon photo-electric cells for its operation. In making Bessemer steel, a charge of molten iron is placed in a converter, and compressed air at about 20 pounds pressure is blown through it. The oxygen in the air reduces the carbon, silica, and manganese to oxides and eliminates the greater portion of them. In practice, the silica and manganese are first reduced, and then the carbon, which is converted into carbon monoxide and burns with a bright flame at the mouth of the pear-shaped vessel. When all the carbon has been burned, the flame drops sharply, and this is a sign that the process has been completed.

Hitherto, the converter has been controlled by the keen eyes of the blower, upon whom has rested the sole responsibility of determining the proper "end point" of the blow. As the quality of the product is definitely dependent upon the correctness with which he gauges the time when to cut off the air, it has been impossible to obtain uniform steel because of the many variables that prevent even the sharpest eyes from erring. The "electric eye" is not subject to these variables, and is capable of split-second regulation. The new method has been thoroughly tried out in the Jones & Laughlin steel works, and is being patented.

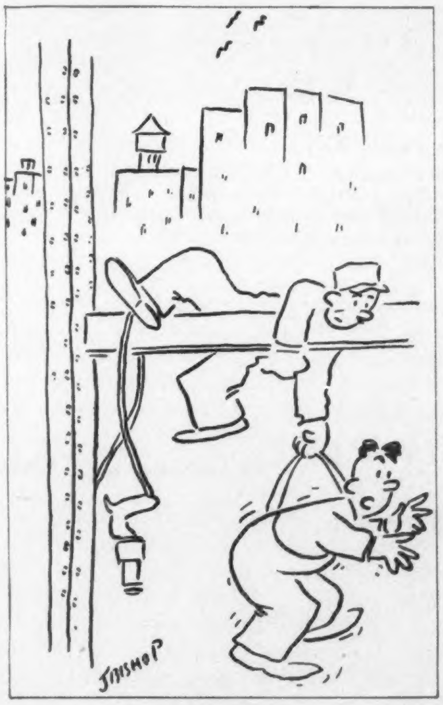
* * *

Loyalty Among Workers

Robert B. Alsop, who is in charge of the rebuilding of the Austin Dam, as described elsewhere in this issue, became a construction man through a visit he paid his uncle, Frank Bainbridge, when little more than a boy. Mr. Bainbridge was a bridge engineer and designer for the Chicago & North Western Railway, and at the time was supervising the building of foundations for a bridge across the Mississippi River at Clinton, Iowa. Mr. Alsop started as a timekeeper for The Foundation Company. He remained with that organization for twenty years and during that period worked on more than 30 sizable undertakings. These were of varied kinds, but at least nine of them were shaft-sinking jobs principally in the iron country of Michigan and Minnesota. On these, as well as on many building-foundation jobs, he became thoroughly familiar with caisson work under air pressure. During his fledgling years he worked variously as bookkeeper, purchasing agent, concrete foreman, materials man, night superintendent, and assistant superintendent.

One outstanding accomplishment to his credit that is well known in the construction field was the speed with which he built the Columbia power station in Cincinnati for the Columbia Gas & Electric Corporation in 1924 and 1925. The entire plant was completed eighteen months after the first carload of material was delivered, setting a record for a job of that character and size that seldom if ever has been equalled. Mr. Alsop went to Texas in 1936 to superintend all construction work for the Lower Colorado River Authority, and is now engaged in rearing his third dam in that capacity.

The one thing that has impressed Mr. Alsop most in his 30 years of activity is the loyalty and faithfulness of men in the construction field to their jobs and to their bosses. Although the work is often hard and at times dangerous, he has found that there are few shirkers and that an engineer or superintendent who deserves coöperation is never forsaken when he needs help. Mr. Alsop evidently has good reason to feel



Saved!

as he does, for at the Austin Dam he is being assisted by six men who have been with him most of the time for periods of from fifteen to twenty years each. These are: Philip La Salle, job engineer; Sam Strong, general carpenter foreman; William Lowitz, general rock foreman; Frank Gilman, labor foreman; Herman Wiren, general pipe and pump foreman; and Charles Mullen, night superintendent. In the death, last October, of A. C. (Tony) Cerney, general foreman, he lost the dean of all his lieutenants. Mr Cerney had been with him for 30 years, and in the words of Mr. Alsop, "A truer, more faithful, and more loyal friend and helper than Tony Cerney had been cannot be found."

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Horizontal Oil Wells Suggested

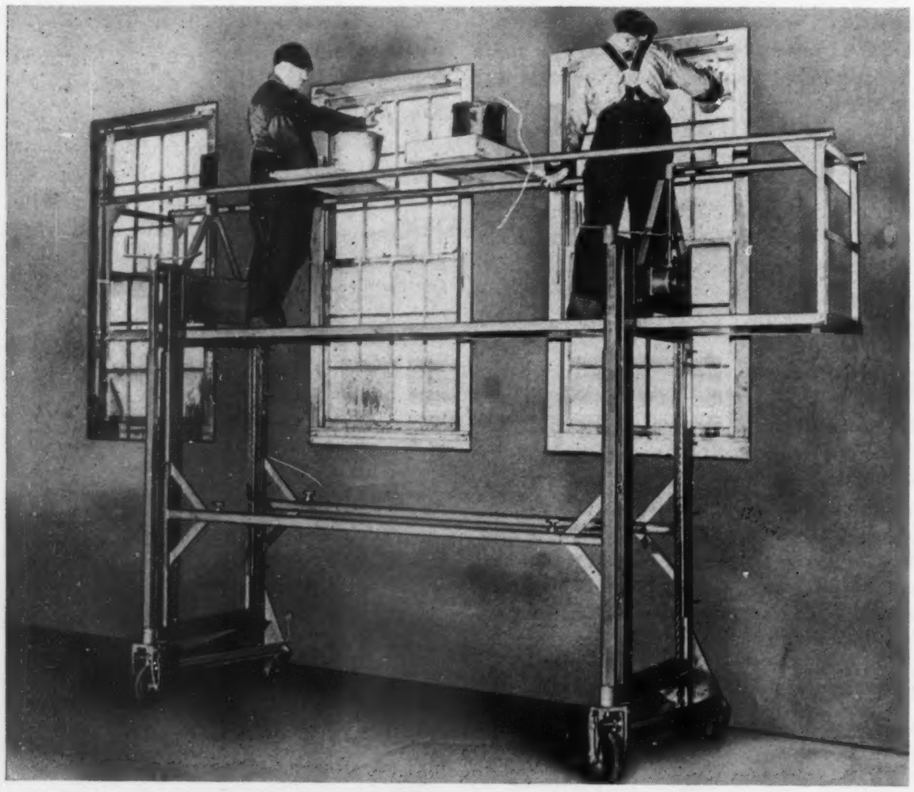
It is common knowledge that under present production methods, when an oil field is abandoned as depleted, more petroleum remains in the ground than has been taken out. Various measures for improving this situation have been suggested, the latest one being a scheme proposed by Leo Ranney to drill wells horizontally instead of vertically. He would sink a shaft to the producing horizon and drill radially from its bottom, this to be done, of course, after flush production had taken most of the gas pressure off the formation. Oil would then flow to the shaft and could be pumped to the surface.

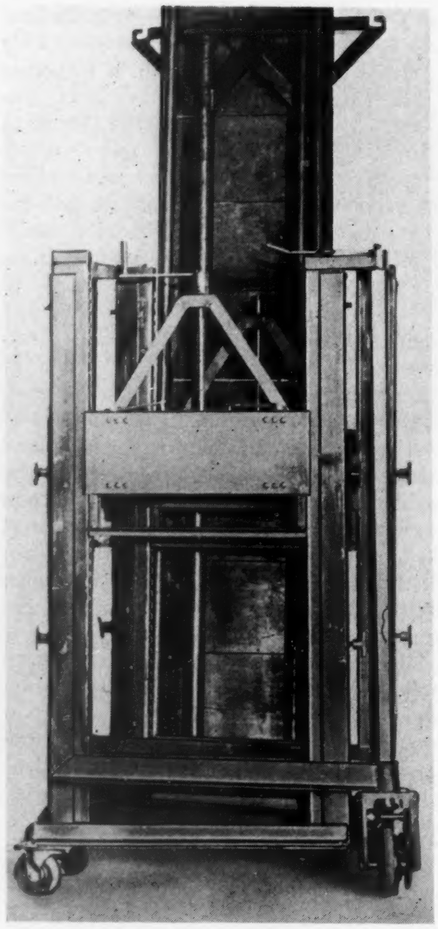
In an effort to prove the practicability of his method, Mr. Ranney recently drilled such a well in Morgan County, Ohio. To save shaft-sinking costs, he chose a location where a proven oil-bearing formation outcropped on the bank of a stream. Oil had been obtained there since 1870. The entire field had been extensively drilled and was finally abandoned in 1930. A hole was drilled a distance of 802 feet, entirely in the oil-bearing rock, the tools retracted to a point 630 feet from the rock face, and a branch drilled from the first hole a distance of 930 feet. A diamond core drill, with drill rods in 60-foot lengths, was used.

To break up the rock and to form channels in it through which the oil might drain to the first hole, the branch hole was shot with 1,150 pounds of 80 per cent dynamite, the charge being distributed over a stretch of 565 feet. Individual cartridges 60 feet long were made up, and these were connected with Cordeau Bickford for firing. The shot was stemmed with water under 200 pounds pressure. From the amount of sand afterward removed from the hole, it was computed that the shot enlarged it to 20 inches in diameter. After shooting, the well blew for about 20 minutes and flowed by beads every 40 seconds for about half an hour. On the following day it produced at the rate of a barrel of oil every five minutes, before becoming clogged with sand.

Mr. Ranney believes that his scheme is feasible, and has applied for some 30 patents covering it. He estimates the cost of developing a field by the horizontal method at about $400 an acre. He states that air pressure could be applied to put pressure on alternate wells, thereby increasing the flow from producing wells that would be further stimulated by pulling a vacuum on the wells. It is reported that a major oil company is now planning to try out the method from the bottom of a 350-foot shaft in Ohio.

Self-Elevating Scaffold Car for Indoor Use





IN WORKING POSITION

A Scafol-Car of standard type used for window-cleaning. When fully elevated it has an over-all height of 12 feet 2 inches representing a lift of 7 feet 9 inches. The men raise and lower themselves and move their working base by turning the cranks above the platform When not in use the unit can be collapsed, as seen at the right.

FOR overhead work of all kinds that usually calls for the use of stepladders or of improvised scaffolding, the Economy Baler Company has designed and put into production a Scafol-Car that seems to combine simplicity with adaptability. It was developed primarily to give men who must toil high above the floor level a safe working platform that they can readily handle, adjust, and move about according to their needs.

The standard type is built for service where there is a maximum headroom of 16 feet. Collapsed, it requires 16 square feet of storage space. When needed for any one of the many jobs for which it is intended—such as washing windows, painting, assembling or servicing machinery, and for maintenance operations generally in factories, department stores, office and other buildings, etc.—the Scafol-Car can be easily wheeled into place and set up.

With the platform in the lowest position, 18½ inches above the floor, the workmen can lift themselves and their tools and equipment to any height within the scaffold's limits, the topmost elevation being approximately 9⅞ feet above floor level. The length also is adjustable, and can be varied anywhere from a minimum of 5 feet to 10 feet. Raising and lowering is effected by means of a crank mounted on the platform, while another crank, which causes the bottom wheels to turn, enables the men from their elevated station to roll the unit backward and forward or sidewise, as may be desired, at the rate of 30 feet a minute, it is claimed. The platform is of solid construction to assure a firm support and footing, and is surrounded by a railing permitting the men to use both hands with safety in whatever work they may be called upon to do.

Meaning of "Thixotropy" Explained

LAYMEN whose activities lead them occasionally into the field of colloidal phenomena, says Paul M. Tyler of the U. S. Bureau of Mines, may be grateful for a nontechnical discussion of "thixotropy," a relatively new addition even to the scientist's vocabulary. The authority in question tells us that a gel is thixotropic if it is liquefied to a sol on shaking and forms a gel once more when allowed to stand. The word "gel" is virtually equivalent to "jelly," while a "sol" means a mixture of colloid and liquid that is still liquid. But jelly, like ordinary glue or gelatine, is a reversible gel—that is, it is altered to a sol by heating, whereas the thixotropic kind miraculously changes when being stirred or shaken.

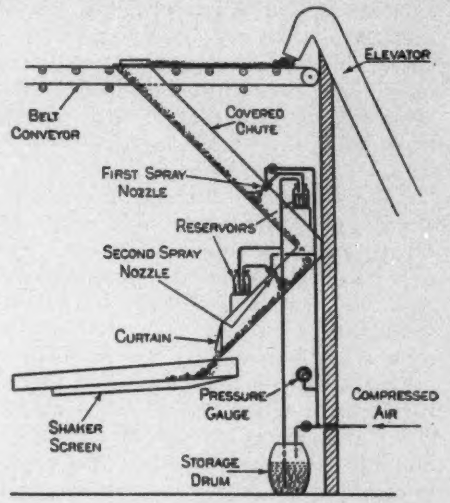
Rotary-drilling mud is one of the most important thixotropic materials. In drilling oil wells, mud is pumped down the drill pipe of a well to flush away the cuttings and to bring them to the surface through the outer casing, to seal the wall of the hole, and to prevent gas pressure from blowing out of the hole. Formerly, the high-density mud used tended to settle and to pack solid when drilling operations were halted, with the result that tools were apt to break when work was resumed. This difficulty is avoided by adding suitable proportions of bentonite. Muds so treated set to a soft clay when not agitated: when drilling is started anew, they again become fluid. Such muds are extensively utilized by oil companies the world over. Bentonite is a bedded plastic clay, and virtually the only inorganic material that swells greatly when it comes in contact with water. Because of this property, it is being used increasinly on construction and building jobs to make pervious soils impervious.

Molding sands also are thixotropic, and the casting of clay in porous molds is another thixotropic action. Modern newspaper inks, consisting largely of carbon black combined with mineral oil, are extremely thixotropic, and certain important paint-industry problems may be solved through this new science.

Air-Spray System for Dustproofing Coal at the Mine

TO DUSTPROOF coal satisfactorily, it should be turned during the cleaning process so that all faces are presented to the spraying solution. This is a primary consideration, according to the British Fuel Research Station, where experiments are being conducted to determine the effect of calcium chloride or oil on different kinds of coal. By the simple expedient of causing the coal to flow first in one and then in the opposite direction in an enclosed chute, and spraying it before and after making the turn, the investigators succeeded in coating it thoroughly. The set-up by which they accomplish this is interposed between the conveyor and shaker screens, the point in the surface plant best adapted for the work because the dust is well settled before the coal reaches the screens and the shaking serves to distribute the oil and helps to spread a thin film over the separate pieces.

As the accompanying line drawing from *The Iron and Coal Trades Review* shows, each of the two nozzles or atomizers has its own oil reservoir, which is replenished from the main storage drum on the ground level. The transfer is effected by means of compressed air, and air at 60 pounds pressure is used to apply the fluid. The reservoirs are provided with immersion heaters so that the oil can be sprayed either hot or



cold, depending on its viscosity. The amount of oil required is not appreciable, and depends on the kind and the size of the coal being treated. In this case about 10 pounds per ton was used. The system has given satisfactory results.

Bauxite for Refining Lubricating Oils

THERE is a growing tendency in fields producing paraffinic oils and those that can be rendered paraffinic to use bauxite instead of fuller's earth for decolorizing lubricating oils by the percolation method. According to *Mineral Trade Notes*, it is already being employed extensively for that purpose in Pennsylvania and in the Mid-Continent field. However, the substitute material does not seem to work so well with asphaltic or with naphthic oils and is therefore not in demand in Texas and California.

Before it was applied on a commercial scale, experiments proved that bauxite is only about half as efficient by weight as a good grade of natural fuller's earth. On the other hand, because of its far greater density, it is 90 per cent as efficient by volume. Its primary advantage is that it can be revivified indefinitely, whereas fuller's earth loses its effectiveness and must be discarded after it has been revitalized twenty times. Shrinkage at each burning amounts to approximately 1½ per cent, so that even bauxite has to be renewed. But as it has a life of about 67 cycles, its higher cost is more than justified wherever the character of the oil is such as to permit its use. Several companies are now engaged in producing bauxite for oil refining.

Underground Exhaust System for Spray-Painting

SPRAY-painting is usually done by men wearing respirators and in special booths or partitioned-off spaces as a precautionary measure against noxious fumes and fire. It is therefore surprising to see this work being done right out in the open within a few feet of all the other manufacturing operations and by men who are not protected with the familiar breathing apparatus.

NO BOOTH—NO RESPIRATOR

On the lathe-assembly floor of the Monarch Machine Tool Company plant showing a unit in the process of being painted. Mounted on small dollies which run on tracks, one lathe after another is moved on to the grating of the underground exhaust system which removes the solids and moisture from the air and discharges the latter into the atmosphere at the rate of 22,400 cubic feet a minute.

Through the installation of a new exhaust system, the painting of lathes in the plant of the Monarch Machine Tool Company is done on the assembly floor and without walls or screens to segregate the sprayer. One after the other, the machines are run over a 7x12-foot grating in the floor. Through this grille the fumes set up in the course of the operation are drawn at the rate of 200 feet a minute, passing into a large tank directly beneath where a continuous cascade of chemically treated water extracts the solids from the air. The substance precipitated is like sponge rubber and noninflammable. It can be readily removed from the pit. The moisture-laden air is carried off through an underground tunnel and exhausted through a stack into the atmosphere. But before it is discharged it filters through eliminator packs which extract the water, together with its chemical content, for re-use.

By means of the new system, in which the fume-laden air is drawn down instead of up, painting can be done safely, it is said, so long as the work does not require the operator to hold the gun over his head—that is, which at no time places him between the spray and the exhaust. The draft is so strong than any paint not deposited on the surfaces is immediately sucked down, and there is no danger either of inhaling the fumes or of spreading them throughout the shop.

Industrial Notes

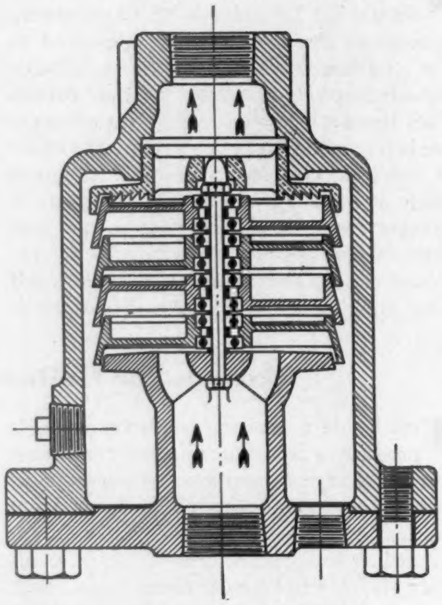
It has been discovered that the addition of as little as ¼ per cent of stearic acid to limestone during grinding will cause the resultant dust to become substantially waterproof, thus making it more effective as a fire preventive in coal mines. In the presence of moisture it has less tendency to cake, and can therefore be spread more readily than the untreated material, a characteristic that it is said to retain during exposure in the workings.

The possibility of burning coal dust instead of oil in diesel engines is being considered at the British Fuel Research Station. A diesel, converted to use powdered coal, has been installed there, and experiments are being made to determine what metal is best suited for the making of liners, pistons, and piston rings that will withstand the abrasive action of coal ash. This is done by injecting coal ash at a constant rate into the carburetor intake of a single-cylinder gasoline engine and measuring the wearing parts at regular intervals. Some 27 different combinations of materials have been tested with results that would seem to indicate that one of the primary objections of pulverized coal as a fuel for diesel engines can be overcome.

For rock-dusting, as generally practiced in collieries to prevent coal-dust explosions, the American Mine & Door Company has built a machine that is designed to ride belt conveyors now used extensively in transporting coal in underground workings. The Mighty Midget Dustributor, as it is called, consists essentially of three parts—of a hopper with a capacity of about 80 pounds, or a sack of dust, and of a screw conveyor that delivers the material to a motor-driven fan making 3,450 rpm. As the machine moves along, the rock dust is scattered at the rate of 34 pounds a minute. The unit is provided with two handles so that it can be carried to parts of a mine not reached by the belt conveyor.

New Type Air Separator

FOR removing moisture, oil, dust, etc., from compressed air, the Logan Engineering Company is offering a new separator known as the Aridifier. It consists essentially of a nickel-chromium-gray-iron casing with an inlet at the bottom and an outlet at the top; of a series of aluminum-alloy rotors, with inclined vanes, mounted so that each is free to turn on stainless-steel ball bearings; and of a spider which steadies the rotor assembly. The vanes are arranged like the sails of a windmill, and those in alternate rotors are set in opposing directions so that they will run counter to each other. This prevents the air stream from developing a whirling motion, as it would if the vanes in all the rotors were pitched the same way. A single bolt and nut of phosphor bronze holds the bearings and rotors in position. As the air passes upward through the unit, the entrained moisture impinges against the vanes of the rapidly turning rotors and is thrown by centrifugal force against the casing, flowing down the wall to the bottom, from which it can be drained preferably through a trap. The separator is also suitable for providing clean, dry steam for processing operations and for removing moisture from saturated steam or gas lines.



Wood that has been immersed in a bath of molten sulphur acquires new characteristics. It becomes heavier, stronger, and denser, reports the Ohio State University, where tests are being made for the purpose of finding new uses for this adaptable nonmetallic element. Studies indicate that by plasticizing sulphur with one or another of the available polysulphides, it is possible to make different products ranging in consistency from soft and pliable to hard and resinous. Mixed with various aggregates, it forms a cement that is said to be inert to water, slightly alkaline solutions, and the common acids; that is highly resistant to mechanical impact and abrasion; and that has exceptional structural strength even when subjected to severe temperature changes. In combination with sand and a coarse aggregate such as coke, it can be used as a cementing agent in the centrifugal casting of pipe. Instances have been cited recently of the substitution of sulphur for barium sulphate or iron oxide in circulating fluids required in the drilling of oil wells. Familiarly know as mud, the fluid serves to cool the drilling bit, to cushion the weight of the drill pipe, to carry off cuttings, and to seal off any water in higher formations.

WATER CURTAIN FOR PAINT-SPRAY BOOTH

A sheet of water flows down the wall at the right while paint or lacquer is being sprayed. At the same time, the air within the booth is exhausted through a narrow aperture at the bottom of the water curtain. The water and air jointly draw off the fumes and spray, thereby protecting the health of the operator and reducing the fire hazard. The water contains a chemical that absorbs any paint or lacquer that may be trapped. This is one of eight new booths in the Endicott, N. Y., plant of International Business Machines Corporation. Blowers draw 46,100 cubic feet of air per minute from outside the building and through the booths. It is heated in winter and cooled in summer. Water is supplied to each booth at the rate of 22 gallons a minute.

Compressed Air in Nation's Largest Prison

CONSTITUTING the equivalent of an independent state within a state, there are represented at the California State Prison at San Quentin, largest penal institution in the United States (population 5,200), all the trades and industries to be found in a community of far greater population and area. Steam and electricity are industrial servants there as elsewhere, being employed at varied useful tasks. Compressed air, too, is recognized as an indispensable form of power, and is applied in numerous ways.

The jute mill is the heaviest employing and greatest producing department, annually manufacturing some 5,500,000 burlap bags from raw jute. While some of the machinery in the mill has been in service for many years, most of it is comparatively new, and all of it is maintained in splendid mechanical condition. A 12x10-inch, single-stage compressor, driven by a 30-hp. motor, provides compressed air for cleaning purposes, for operating the various small air tools necessary, for maintenance work in the mill, and for cleaning boiler tubes.

The boiler room has equipment for emergency use whereby compressed air can be substituted for the steam ordinarily required to drive the oil pumps and boiler-feed pumps. In the event of a broken oil line or of water getting into the oil—any mishap causing the boiler pressure to drop below that needed to drive the boiler-feed pumps—the compressor is started and air is substituted for steam. By this arrangement it is also possible to raise steam even in a "cold" boiler. After the latter has been brought to the required pressure and the trouble has been remedied, normal operation is resumed. Standard high-pressure pipe and fittings are used for all air lines and, as the air is transmitted short distances, loss of pressure is negligible.

At the quarry, rock is taken from an open cut in quantities and sizes suitable for the hard-surfacing of roads, the building of hand-laid retaining walls, and for other local construction work. This rock is of two distinct types: the first and more prevalent being so-called "trap" rock, and the second a comparatively soft and porous shale which readily breaks to rough pattern if desired. The shale is used principally for fills and for reclaiming low tidelands along the bay shore.

Equipment at the quarry includes two Ingersoll-Rand compressors: a 12x10-inch Class ER-1 unit powered by a 60-hp. General Electric motor and a Type XRB-2 15&9¼x12-inch machine which is belt driven from a 100-hp. Westinghouse motor. Drilling is done with Ingersoll-Rand Jackhamers and Jackbits, and the latter are resharpened at the prison blacksmith shop. The maximum depth of holes is 20 feet, the number drilled and shot at a time varying with the amount of rock required for immediate use.